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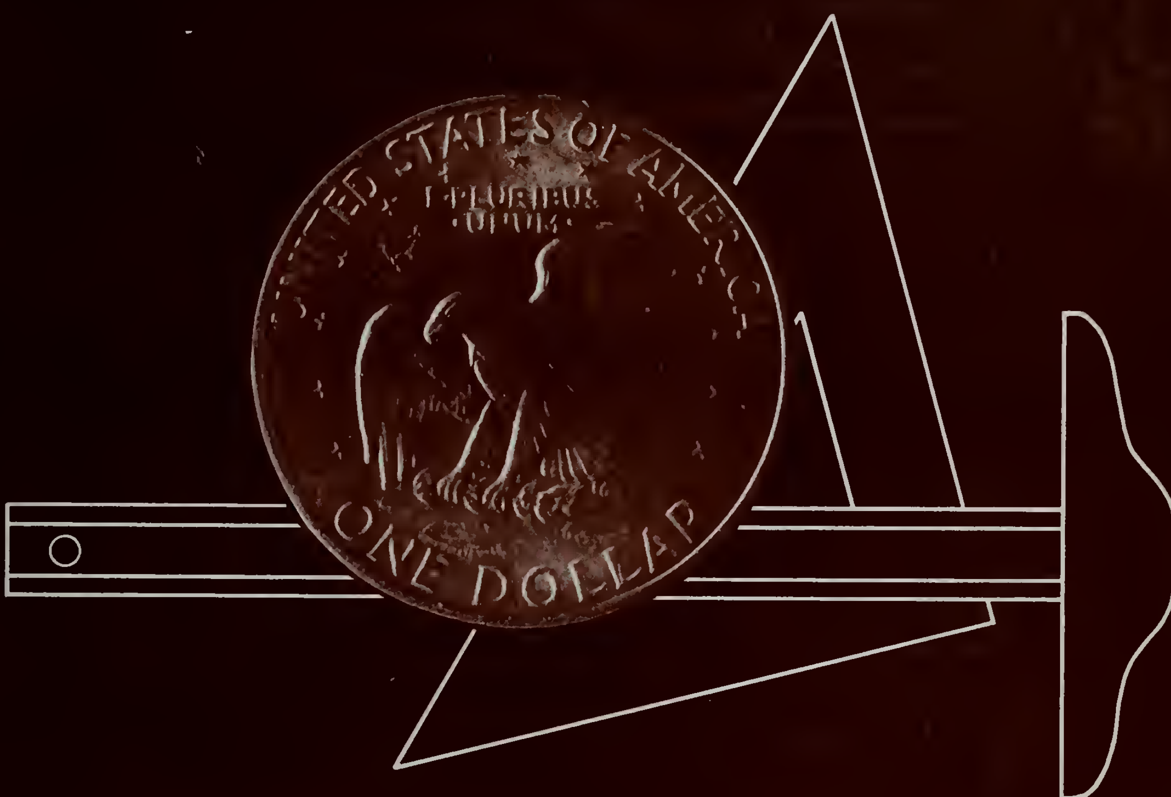
# defense management JOURNAL




## Design to a Cost

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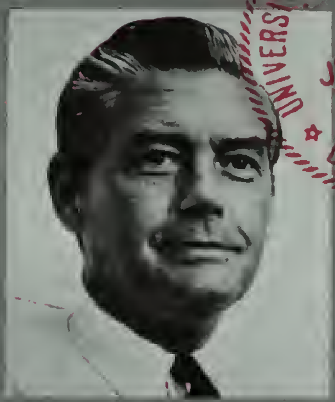


**by Leonard Sullivan Jr.**
***Director***
***Defense Program Analysis & Evaluation****

The principal responsibility of Defense Department managers is to provide the necessary military strength to support the President's strategy for peace—strength, partnership and a willingness to negotiate. The challenge to the Defense Department is to provide this strength in an era of rising prices, shrinking budgets and changing priorities.

A recently completed assessment of ongoing defense system development programs showed, in almost every area investigated, that the estimated cost of the new systems, assuming the projected DOD budget, would substantially exceed our ability to buy them in the needed quantities. The basic cause of this dilemma is the tremendous rate at which the cost of individual systems is rising.

One underlying cause of rising unit costs has been our desire to provide systems to our forces which, on an individual basis, were the very best that technology could provide. In the process, we assumed funds would be available as needed to procure the requisite numbers of these systems. This assumption ignored economic realities. While costs have risen, the DOD budget has remained relatively fixed in overall purchasing power; and there is little prospect the Congress will appropriate larger DOD budgets.

Furthermore, concern for improving the quality of life for the men and women of the Military Services has generated new demands which must be fulfilled from limited resources. When all demands on the DOD budget, as well as the Federal budget, are considered, the conclusion is inescapable. The future available resources for investment in developing and procuring new systems will be comparable to those now budgeted. We can no longer afford to develop every individual system for maximum

* *Mr. Sullivan was Principal Deputy, Office of the Director of Defense Research and Engineering, until he assumed his new duties May 21.*

performance; rather, we must balance performance, numbers and cost to achieve the greatest total military capability from our available resources. We must learn to consider total force effectiveness rather than each individual weapon's cost effectiveness. We must recognize a broad variety of possible utilizations for these forces—not just the single "worst possible case," *i.e.*, a one-on-one encounter with the maximum capability threat.

Assuring affordability of new systems has become a major DOD objective and is the driving force behind the design to a cost concept of development. By deciding approximately how much we can afford to spend on a particular mission area and its systems and then designing to that target cost, we hope to control our acquisition and ownership costs, thus assuring that the most capability is derived from our resources.

We have initiated a number of specific design to a cost development programs from which we are learning how to structure and manage such developments. We are designing major systems such as the Air Force's A–10 close air support aircraft, the Navy's patrol frigate and the Army's advanced armed helicopter to strict unit production cost targets. We are also designing subsystems such as the low cost electronic warfare suite for the Navy, a new tactical air navigation system (TACAN) for the Air Force and a new radar altimeter for the Army to firm unit production cost targets.

In all development programs, we are emphasizing field reliability and performance, but not to the exclusion of unit production cost. DOD developing agencies and the defense industry must understand and accept the fact that we want the most reliable and capable systems possible at the established cost. We do not want "cheap" systems whose value may be inadequate. When we established the target costs for the previously mentioned design to a cost systems, we believe we studied the problems sufficiently to ensure our real minimum performance needs could be met within the cost if careful design and good management were applied. In some cases, as the developments progressed, we had to revise our initial cost targets. Such changes are to be expected as we learn how to apply the design to a cost technique.

To ensure this technique received adequate attention, it has been made a part of the DOD decision-making process including reviews by the Defense Systems Acquisition Review Council (DSARC). For example, when the Army recently proposed its plan for the development of the new armed helicopter to the DSARC, the estimated cost of the system was over $2 million for each aircraft. Members of the DSARC recognized the need for an armed helicopter, but believed one with all the essential capabilities could be produced for substantially less. Therefore, a lower cost ceiling was established and the Army made the necessary changes. The program is now proceeding with a cost target in the range of $1.5 million.

In a similar manner, either the DSARC or the Military Services recently established unit cost thresholds for the Army's main battle tank, the Navy's patrol frigate and the Air Force's medium STOL transport aircraft.

There is no intention under the design to a cost concept to bargain away the necessary edge in combat performance; there is, however, an implication that some of our systems may contain characteristics which cater more to luxury than essentiality. Identification and elimination of these extras is one goal of this new approach.

While we are still learning how to effectively manage design to a cost developments, we are no longer questioning the potential of the concept for helping to control the cost of acquiring new defense systems. Its potential has been adequately demonstrated in our ongoing developments and the need to extend its implementation is clear.

The design to a cost technique is not unlike that used by commercial firms to remain competitive in the marketplace. One of its most valuable contributions is to make defense design and development engineers accept cost as a basic decision parameter down to the individual component level. Another important contribution is that the design to a cost concept strongly suggests DOD program managers and contractors should be given greater flexibilty to trade off design features independently. This represents an important step in returning the authority for creativity to those best able to exercise it.

In essence, we now have sufficient confidence in this new methodology to put many more new and ongoing systems and subsystems on a design to a cost basis.

# Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost

An important change is taking place in the acquisition process of defense weapon systems. This change has been brought about by the recognition of a serious dilemma that faces us involving a conflict between the rising production and ownership costs of the sophisticated systems we need to defend the Nation and the budget realities that tell us we cannot afford the quantities of equipment we must have to maintain the already low force structure at a sufficient level.

It has been frequently demonstrated that demands for increased performance have led to equipment sophistication and, therefore, increased costs. While it is true that some reduction in equipment quantity can be offset by increased equipment capability, the time is rapidly approaching when this trade-off is no longer going to be a viable option. Put simply, a better way must be found to provide our forces with the needed quantity of useful equipment within budgetary constraints.

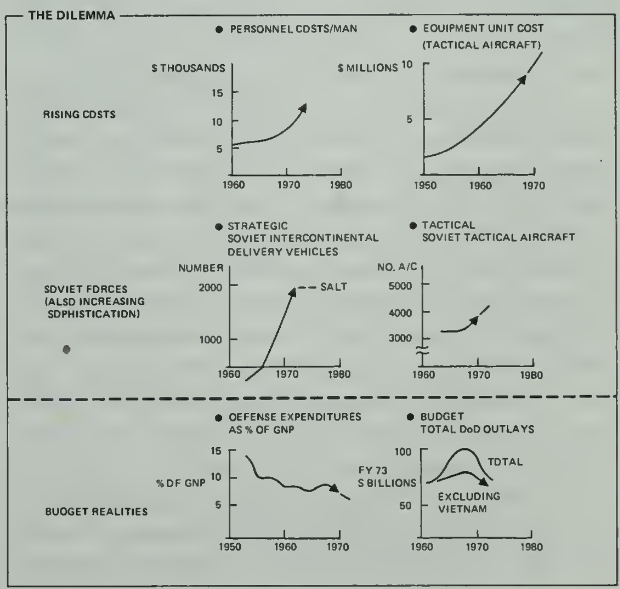
Our present problems originate in the requirements process. Uncertain of exact needs, we frequently err on the safe side, *i.e.,* ask for maximum potential performance. Industry contributes to the problem with proposal promises.

**Jacques S. Gansler**
***Assistant Director (Electronics)***
***ODDR&E***

By the time production price or ownership costs become a firm consideration, the development is so far along it cannot be readily changed. The net result is that we ultimately get exactly what we have specified: systems which satisfy our performance needs. The difficulty is their price often exceeds our ability to buy them in the quantities required.

## Three-Pronged Attack

To solve the DOD cost and reliability problems, we are adopting a different acquisition strategy and are changing our approach to the



defense system specification, selection, development and maintenance processes. Shifting from an almost exclusive emphasis on achieving the highest possible state-of-the-art performance in every aspect of every system, future emphasis will be placed on obtaining the best possible overall defense posture for the budget dollars available. This means that, during all phases of equipment development, we will place as much stress on projected unit production costs and field reliability as we place on system performance.

To achieve these goals, emphasis is now being placed on three approaches to the solution of the problem:

- *Design to a price.* This concept is not new to the commercial world where equipment is designed to sell at a price which market analysis shows the customer will be willing to pay. Similarly, in the defense area, design to a price means that DOD will establish a unit production price that the defense budget allows and that reflects the military value of the equipment. Attainment of that price will be made a criterion and a condition for procurement. Design within the target price will allow procurement of production hardware in the quantities that will fulfill military needs. If a system does not satisfy certain minimum acceptable performance specifications, DOD will not buy it. The goal of the design to a price concept is not "cheap" equipment, but rather quality equipment which will satisfy military needs at a price allowed by budget constraints. Competitive development and prototyping will be stressed, with a "fly-off" to select the best equipment for the desired price.
- *Standardization.* Greater application of standardization will be applied in the design and development phase of a defense system. We will attempt to standardize on selected subsystems for multi-service and multi-vehicular applications to assure maximum benefit from the quantity-based "learning curves" for cost and reliability. The primary impediments to standardization in DOD are institutional ones and we intend to work at changing them. Standardization is a major step in our cost-reliability "attack."
- *Holding the Supplier More Responsible for the Field Reliability of His Equipment.* In this area perhaps some type of warranty is the best approach to obtain field reliability of equipment, particularly in the subsystems area. It might be in the form of a supplier's repair warranty, as in commercial avionics, or it might be in the form of a field reliability warranty which, if not achieved, would require the supplier to redesign and retrofit. Field reliability will be measured under a condition in which all failures will count, regardless of cause (design induced, wear-in, random, wear-out, etc.) and under which time is actual equipment operating time as measured by built-in elapsed time indicators.

**Within the past 20 years the cost of defense weapon systems and manpower has been rising at more than five times the rate of inflation. The extra money to pay for these rising costs is unavailable because at the same time all the growth in the Gross National Product (GNP) within this same period has gone into the non-defense sector.**

**The need for national security forces continues to grow with the increasing size and sophistication of the arms of potential adversaries. The reduction of the defense procurement dollars raises the question, how do we get more for less? The answer is not simple, but we must make a strong effort to reach some kind of a solution before we're out of business.**

**We can and must draw more heavily on commercial experience and move in its direction in design objectives, technical requirements, management perspectives, engineering design, data and field support. The Defense Department, to continue to acquire weapons systems, must design to a cost, utilize greater standardization and require greater supplier responsibility for field reliability.**

## Right Direction

It should be clear these proposed solutions to cost and reliability problems are taking DOD further in the direction of commercial practices. We must not, however, lose sight of the

DOD must establish a price per item copy that is compatible with both the minimum required military performance and with what we can afford to pay for the quality number of products we need. Products that are just inexpensive are not acceptable. Military needs must be met or we will not buy the equipment. To accomplish this, we are willing to pay more in time and dollars in the R&D phase to assure achieving the desired unit production price and support costs. Hopefully, we will also be writing functional specifications rather than detailed design specifications and perhaps, in this way, provide the designees with sufficient flexibility to develop solutions leading to low-cost and high-yield reliability systems.

Through the current emphasis on the design to a cost concept, we hope to achieve this goal. Design to a cost is *not* a return to total package procurement. The new policies emphasize incremental acquisition and early flexibility in design specifications. The design to a cost practice is spreading and working as the cost incentive stimulates industry engineers with additional challenges.

Determining the right price will take work, but the inclusion and utilization of standard parts will result in high-volume production and lower cost and higher reliability, while greatly reducing the logistics and training costs. Standardization implementation will be difficult, but the potential rewards are great.

Specifications must be written to encourage standardization and the designer must be allowed flexibility if standardization and design to a cost are to work. In essence, then, we must change the objectives of the R&D community from the overriding emphasis on improving the state of the art in performance, to an emphasis on *quality* equipment having an *acceptable* performance for an *affordable* cost.

The key to implementing these new concepts lies in Government and industry management. We must demand more discipline on *both* sides in controlling costs and that ever present human frailty of trying to acquire those last few percentage points of performance. Cooperative management demands the best efforts of all of us.—*Dr. John S. Foster Jr., Director, Defense Research and Engineering.*

necessity to satisfy military performance needs in the military environments. Thus the transition is not one from total military performance-oriented thinking to total commercial price-oriented thinking. Rather, it is a change from performance only to the addition of cost and reliability as major design criteria, with the belief that low production cost and high field reliability are truly designed into military equipment and not achieved afterward.

Also, in stressing the new approaches, the Defense Department is not abandoning high technology. We will continue to advance the state of the art, but we will only apply new technology when it is firmly required and its feasibility has been satisfactorily demonstrated. In those cases, DOD will pay for the extreme performance, but only for small quantities of systems. Thus we will have a mix of a few high technology, high cost systems and larger quantities of reduced performance systems—the so-called "hi-low" mix.

## Total Cost of Ownership

Price limited development is a step by step process. First, feasibility studies are conducted to show practicality of the price/performance range under consideration. Second, cost-plus development contracts are awarded to develop prototype hardware which meets the production price goal. Third, the prototypes undergo operational test and evaluation to demonstrate their military performance, reliability and maintainability. Finally, the designs are ready for selection and release to production. Competition among the suppliers is the mechanism which provides DOD with the most performance that can be delivered at the specified

unit production price.

To ensure suppliers understand the relative value which DOD places on each of the functional and performance parameters, relative importance "weights" for each must be provided. These same weighting factors would subsequently be used in the equipment test and evaluation and in the contractor selection criteria.

Total investment costs will be further minimized by designs that reduce the required documentation data, special test equipment, required installation costs, required training, etc. Life cycle costs, in turn, can be significantly reduced by achieving higher field reliability. This can be attained, in part, by considering the achievement of field reliability and maintainability goals to be as important as the achievement of high performance. Low cost and high reliability can go together. A clever, simple design may be harder to arrive at, but it will achieve the desired objectives, and often without a significant penalty in performance. It is more of a challenge for the engineer, but it is worth the effort if it is successful.

The goal of the price limited development is, therefore, to ensure DOD obtains quality equipment which will perform the necessary military mission and which DOD can afford to acquire and own in the quantities necessary. The proposed approaches previously described should reduce unnecessary and unproductive specifications and overhead burdens which increase production price without increasing the equipment's utility or functional value. By establishing a unit production price before development, DOD will have a better opportunity to control the cost to acquire. Through emphasis on reliability, ease of repair, extensive testing, warranty and maintenance options, maintenance costs should be reduced. Collectively, these controls should reduce the total life cycle cost of the equipment.

## Achieving Change Not Easy

We recognize bringing about the needed changes in DOD procurement will not be easy. We must change our way of thinking and create new incentives for DOD program managers and industry; we must change our procedures and, if necessary, modify our institutional structures. In bringing about these changes, we will draw upon the experiences of industry where technological advances have resulted in both improved performance and drastically reduced prices.

To institute these changes will require convincing people that we have a problem and motivating them to solve it. Cost consciousness must become a way of life and must affect all phases of system specification, design, fabrication and maintenance. This must happen at all levels in DOD and industry.

We must develop and test procedures for implementing these changes. Changes will not be made solely for the sake of changing. We will develop and test the changes themselves to make sure they are proper and will achieve our objectives. A series of studies has been started by the Office of the Secretary of Defense and the Military Services to examine these areas. In addition, each of the Military Services has a number of experiments under way which will develop new hardware that is required in large quantities but for which the current products are either too expensive or too unreliable, or both. The purpose of these experiments is to achieve performance similar to what we can achieve today, but at significantly lower cost and higher reliability.

The most difficult part of our task will be to institutionalize the desired procedures after we have tested them. It is always easier to do something on a single case basis than it is to make it happen automatically for all future systems.

## Broad Scope Action

Our approach to the solution of the DOD cost versus quantity dilemma must be broad. It must examine and, if necessary, change many aspects of the development and acquisition process. We must start with the requirements process and be willing to trade performance and costs. Our specifications may indicate desired performance, but they must require only the minimum acceptable performance, and they must make production and ownership costs key design criteria. We will have to modify our contractual requirements to reduce unnecessary paperwork, reports and other

*(please turn to page 61, col. 1)*

# Design to a Cost: Concept and Application

Historically, DOD development managers have been charged with the responsibility for creating defense systems to meet operational performance and schedule requirements. Costs, apart from the availability of funds to support the developments, were frequently not the primary consideration.

In contrast, development managers in commercial industry are usually well informed of the cost targets for their new products which are developed from the outset to sell at an attractive price for performance conscious buyers in a competitive market.

The advent of rapidly rising costs of developing and supporting defense systems has led to the adoption and application of the design to a cost technique to systems developments undertaken by DOD. The scope of the design to a cost approach includes the requirements and development processes, production, testing and early operation.

There is a fundamental impact on the DOD requirements process in which price and quantity relationships are to be derived and considered as primary design parameters in the formulation of goals for new systems. That is to say the cost impact of weapon systems performance features should be visible during an iterative process in which the minimum performance needs and the affordable unit production cost are firmed up and determined to be compatible.

Cost and quantity goals must be approved by the responsible manager prior to initiation of advanced development. This, in effect, establishes a target cost or cost bands which will be primary parameters (equal to performance) in the development and acquisition phases.

During the development process, flexibility must be maintained to allow cost and performance trade-offs with the objective of acquiring the best performing system within cost and minimum performance bounds.

Application of the design to a cost technique to DOD development programs has emphasized these significant changes from methods followed in the past:

- Use of end item performance goals and minimum acceptable form, fit and function specifications in lieu of firm technical specifications for systems, subsystems and components.
- Contracting procedures and methods which give development managers maximum trade-off flexibility among performance, schedule, reliability and maintainability.

**by Cdr. Floyd H. Hollister, USN** **and** **Russell R. Shorey**

***Office of the Assistant Director (Electronics)***

***ODDR&E***

• Maintenance of competition to the extent possible in all stages of development up to and including production.

• Emphasis on unit production cost and other life cycle cost components, with cost visibility, during the development phase.

• Incentives for exceeding goals and penalties for failing to meet minimum acceptable specifications.

• Verification of performance, reliability, maintainability and unit price prior to a major production commitment. Emphasis on test and evaluation (as opposed to paper studies) as the means of verification.

### Reliability and Maintainability

In design to a cost development, reliability and maintainability are especially important considerations. There is concern that a developer, motivated to provide the highest level of system performance possible at a target cost, may implicitly trade reliability and maintainability for greater performance. DOD has experienced this problem in past developments where such trades have been made for either additional performance or lower R&D or production cost. Three approaches are being taken in design to a cost development to ensure adequate reliability and maintainability results:

• Minimum reliability and maintainability requirements are established along with other minimum acceptable performance specifications. These are treated as major system performance parameters during performance verification. (In one major design to a cost development only reliability and maintainability are the very few items firmly specified; performance is largely allowed to float.)

• System evaluation is structured to include reliability and maintainability tests and demonstrations. Emphasis is on field tests in typical operational environments rather than laboratory reliability demonstrations or extensive paper predictions.

• Warranty or other forms of incentives may be selectively applied to developments to motivate system designers and increase contractor responsibility for field reliability, particularly during the first few years of system life.

### Procedural Issues

There are presently more than a dozen DOD major system and subsystem development programs in progress which embody design to a cost principles, each with a number of differences in the detail of the approaches being followed. The differences reflect the constructive debate among design to a cost advocates over how the technique can best be practiced. Eventually, practical experience will be accumulated which will provide evaluated procedures applicable to the different phases of develop-

**Several years ago, it became clear to many that we would need to make system unit cost a much more important factor in our R&D than had been the case in the past. We were also wise enough to know that to accomplish this would require a major cultural change on the part of almost all the institutions and people that work to help the DOD design and buy weapon systems.**

**Accordingly, for the past several years, DOD and many of its consultants have been considering how to make design to a cost the accepted and general approach to weapons development and procurement. We've set up a number of task forces, in and out of the Government, looking at different facets of the problem. We've undertaken dozens of special studies which have looked at past practices and potential improvements, and we've insisted that a few select developments operate under the design to a cost approach.**

**As a result of all this activity, we think we're more than halfway there. As a matter of fact, we project that within a year almost all new system development projects in DOD will be initiated with a design to a cost approach.**

**Design to a cost is necessary because weapon prices have been continually escalating whereas the projected defense budget has leveled off and its real purchasing power is likely to decline during the rest of this decade. We found that if we priced out over a decade the procurement of major weapon systems finishing development, we would need twice as much money**

as we had; and we were way short of having the resources needed to maintain current force levels, much less develop and buy all the other minor items that we needed.

It was clear why weapon prices were going up. In an attempt to get the best, we had evolved an acquisition system which used new technology to improve performance as much as possible rather than to reduce price. We aimed for weapon systems which performed many missions against many advanced threats. When a development program got into trouble, we were forced to compromise performance or cost and, in almost every case, we didn't relax the specifications. Consequently, the cost inched forward.

Reduced to simplest terms, design to a cost means trading performance for cost until we are assured that a balance is achieved where the needed military performance can be provided at a price we can afford for the quantities we need.

It is important to recognize that design to a cost doesn't mean "cheap" equipment with all the connotations of inferior quality. Our objective is quite the contrary. We need and want quality equipment and intend to use both competition in development and fly-before-buy to ensure we get it. Through the design to a cost and fly-before-buy approaches we expect to achieve better value for our dollars and buy quantities of quality equipment.—*Herbert D. Benington, Deputy Director of Defense Research and Engineering (Information and Space Systems).*

ment as well as to different types of system developments. Among some of the different approaches in the RFP, specification and contracting areas are:

- A reflection of the views of those who advocate the establishment of minimum essential performance requirements and specific guidance concerning higher levels of *desired* (but not required) performance. Others reflect the view that only the operational context and initial targets need to be specified, leaving it up to competing developers to decide how much and what kinds of performance they should supply. Perhaps these differences will be resolved by considering the somewhat different specification needs for the early design, prototype and engineering development phases.

- Another point reflected in ongoing developments is whether to design to unit production or minimum life cycle cost targets. In those developments where unit production cost is the principal design goal, incentives such as warranty or specified minimum levels of reliability or maintainability are employed to control resultant support costs and are backed up by extensive test and evaluation. Generally, it appears use of ownership cost estimates as a major source selection criterion and the use of firm unit production cost* targets, coupled with reliability and maintainability incentives in the contract, is a pragmatic approach to satisfying the broad objective of managing total life cycle cost in the near term. This area, however, needs considerable attention.

- There is an issue concerning the mechanics of establishing the level of the cost target. Should top-down analysis from budgetary allocations be employed? This could work for major weapon systems, but it poses serious problems of relevance for subsystems employed in different major systems. Should the price level be determined by comparison with costs for existing systems of a similar type? If so, what assurance is there these costs are in the right ball park?

- Competition is essential to the design to a cost approach since it is a principal vehicle for ensuring the greatest performance is provided for the price, but how much added development cost can its benefits justify? Can we, for example, afford competition in parallel full scale development of a major system such as an aircraft? In these cases, alternate forms of competition could be provided by updated versions of existing systems, foreign developments or other functionally equivalent systems.

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** Most ongoing developments specify unit production cost targets. There is, however, an important issue of whether or not other elements of acquisition cost such as initial spare parts, special test equipment, documentation, etc., should be included in the target.*

• Concern also exists about the type of contract which should be employed in design to a cost development. To date both fixed price and cost-plus contracts have been used. Typically, when performance has been specified at high levels, cost-plus contracts have been employed because of the uncertainty of the development effort needed to achieve specified performance levels. A similar argument would justify cost-plus contracts when the level of effort warranted to maximize performance within production cost targets or to reduce ownership costs can be just as uncertain.

• Another question which arises in contracting discussions is when to require legally binding estimates of production cost. One ongoing development requires estimates be provided just before prototypes are delivered for competitive testing. Requiring estimates that late in development (as opposed to earlier stages) shows appreciation for industry's concern about undue pressure to provide binding estimates of production cost before hardware is produced upon which to base the estimates.

• An additional problem involves the application of the design to a cost approach to one-of-a-kind system or systems in which development costs are a large fraction of total acquisition cost. For these, it may be appropriate to specify performance and schedule and to select contractors based on lowest acquisition cost. On the other hand, if the needs tend to be open ended, it may be advantageous to specify acquisition cost and to compete for maximum performance in the early phases of design. If development cost is a significant portion of total acquisition cost, then relatively greater emphasis on development cost versus production cost would be warranted. For the latter two cases, some of the design to a cost principles can still be productively applied.

## Applicability to DOD Systems

It is intended that design to a cost principles be selectively applied to a major fraction of new weapon system and subsystem development.

At issue is the extent to which cost can and should be established as a major decision design parameter early in the development phase for those systems which, for national security reasons, must stress the full state-of-the-art performance, or for which the assessed need is sufficiently urgent that performance and schedule trades cannot be made. Such systems will be driven by performance and compete, to the extent possible, on the basis of lowest cost to meet the need. This is the inverse of the thrust of design to cost in which cost is the driving parameter, and competition is employed to maximize performance. The principles of tracking unit production cost during the development process and the maintenance of tradeoff flexibility and incentives to reduce production costs by judicious rebalancing of requirements can still be beneficially applied to those systems where performance is critical. The summary issue in determining applicability is the extent to which the Government must or can let acquisition costs continue to be driven by performance rather than affordability.

## Innovation Needed

The issues raised by initial application of design to a cost techniques to DOD development programs demonstrate the need for significant change in the RFP, specification, contracting and source selection processes introduced by design to a cost development. This technique also requires innovation and change in traditional operating procedures. In source selection, for example, it is important that cost and performance be jointly evaluated and that flexibility be provided which will permit cost as well as performance negotiation.

In the reliability area, it is essential that significantly greater dependence be placed on testing, design improvement and evaluation in operationally typical environments rather than on detailed design guidance and extensive reliability prediction. Adequate time and money must be allocated for these functions.

What is suggested is that a climate be created in which many of the established practices can be examined for their value, relevance and cost impact, that more responsibility be given to development managers, and that innovation for lower cost and higher reliability be encouraged on every front. □

*In Systems Acquisition Process*

# Army Views Challenge of Design to Cost

In the competitive consumer market, industry, as a standard practice, conducts surveys to determine desired product characteristics and the price consumers want and can afford to pay for that product. Designers are then charged with the responsibility of developing items, at predetermined price goals, that will be competitive in the marketplace.

The Defense Department, in applying the design to cost concept, is essentially borrowing a page from industry's notebook in an attempt to solve the dilemma that faces defense managers—the rising cost of acquiring major weapon systems. Production and operating costs in defense system design are an important consideration to assure development of new weapon systems that DOD can afford to buy or operate.

Although a number of factors influence cost of weapon systems, the "nothing but the best" syndrome in the military and in defense industry is a significant contributor to the problem. Military users have insisted on systems that have pushed the technological state of the art. Industry designers and engineers have been eager to satisfy DOD requirements with systems concepts that maximized performance. In other words, we have been totally committed to "designing to performance" with production cost given little consideration. If the trend toward higher cost of systems is to be stopped, a change from this traditional approach is needed. Design to cost provides a potential tool for the defense manager to make this change.

by Maj. Gen. Frank A. Hinrichs, USA
*Commanding General*
*U.S. Army Aviation Systems Command*

The design to cost concept was introduced in July 1971 when DOD Directive 5000.1, "Acquisition of Major Defense Systems," was issued. This directive requires translation of cost elements into design to cost requirements and practical trade-offs between system capability, cost and schedule. Since issuance of this directive, design to cost has been established as a major program to control costs of weapon systems in the future.

## Design to Cost Features

Under the design to cost concept a *unit production cost goal* for the item must be established prior to development. This goal will ensure from the start that industry is challenged during design and development efforts to provide an item of acceptable performance that will not cost more than the Army can afford to pay. The design to cost goal established by the

Government will be the average price per copy for the total number of items programmed for procurement.

Figure 1 provides a pictorial view of the Army application of the design to cost concept to weapon systems acquisition programs. The learning curve will vary depending upon the typical pattern for the industrial area involved. This example illustrates the midpoint of a 1,000-unit lot with a design to cost estimate of $100,000 for each production unit on an 85-percent unit learning curve. The solicitation will normally contain a design to cost range which will provide the designer of the system flexibility in determining his proposal. During contract negotiations, the specification design to cost value will be established based upon the contractor's proposed design and the factors which make up the cost. The negotiated design to cost will contain adjustments for the trade-offs made in the system.

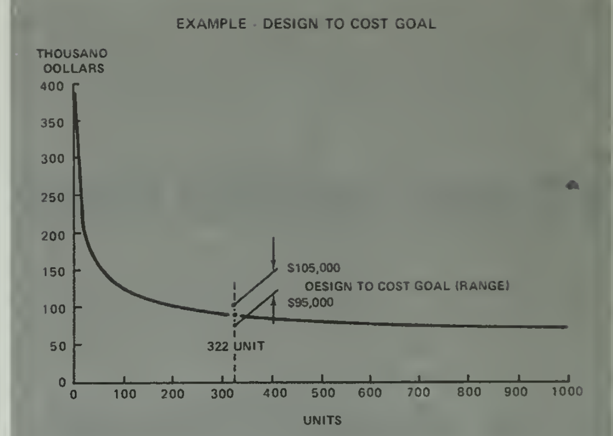

Figure 1

Inherent in the concept is the *element of trade-off*—an essential element if the concept is to be effective. The Army must be able to acquire quality products at or below the design to cost goals. Further, designs that do not provide a significant cost effectiveness advantage over current systems are of questionable value. Marginal and inferior products that are just cheap are not acceptable. The Government is looking for the best balance of performance, cost and schedule which produces a system within reasonable limits. The key words here are "reasonable limits."

A contractor should submit a proposal that is both responsive to system requirements and below the established unit production cost ceiling. The offeror is encouraged to submit a proposal that offers what he considers the best buy. He may propose a concept quite different from that envisioned by the Government, *e.g.*, a single rotor in lieu of a tandem rotor; or he may propose a similar concept including reasonable trade-off proposals which, though falling outside the performance standards, will significantly reduce costs, *e.g.*, a trade-off of five miles per hour of speed for a savings in fuel consumption.

Figure 2 depicts an example of the trade-off concept. The middle of the chart represents the trade-off area. It is in this middle area or band that contractors are challenged and encouraged to submit proposals. This is the area where trade-offs between performance, schedule and cost are expected.

On the chart Proposal A illustrates a hypothetical trade-off proposal wherein performance is proposed below the upper band and schedule at the bottom limits of this upper band, with cost falling in the upper portion of the design to cost range. In Proposal B performance is within the desired requirements; however, a greater slippage in schedule is proposed resulting in a lower unit production cost but still within the design to cost range. Proposal C typifies a trade-off much greater in performance and schedule with cost falling below the design to cost range.

All three of the hypothetical trade-off proposals illustrated in Figure 2 are responsive to the request for proposal (RFP) and would receive considerations. The costs shown for these trade-offs are significantly lower than would have been realized without the application of the trade-off concept.

This philosophy is used to challenge industry to exercise maximum ingenuity and flexibility. Potential contractors for developing a required weapon system must be capable of providing proposals that trade off cost, schedule and performance. This is asking the maximum of industry technical and management capabilities in proposing a system that will be the best buy for the Government's dollar. It will result in systems the Government can afford to buy. Two factors are pertinent to achieving this goal:

- Accepting a higher cost for research and

development to bring about a lower unit production cost. Undue emphasis on development, however, can bring about a reverse result and not an ideal economic one. It is important to avoid emphasis on the ultimate in economy with an unending development program.

• Giving designers freedom to search for greater field reliability at less cost. This freedom can be achieved by employing to a greater extent the bands of performance in specifications instead of specific design features. It is expected that contractors will suggest changes to the RFP requirements that they believe will be of economic benefit to the Government. Subject to trade-offs are military specifications, schedule, performance and other RFP needs to arrive at the most cost effective design.

## Establishing the Right Price

Stating the design to cost concept in simpler terms, an individual contracting for the construction of a new home can think of many features he would like the builder to include. If he has the money, cost is no problem. On the other hand, if he can afford only a $50,000 home and his dream house will cost $150,000, he must make a decision. He can choose the dream house which will be turned over to him one-third finished when his $50,000 is spent or he can select the $50,000 acceptable product even though it doesn't incorporate many of the nice to have, but unnecessary, features of the dream house. The design to cost concept applies this simple logic to acquisition of defense weapon systems.

The biggest problem of the design to cost or production unit cost goal is establishing the right price for the required military capability. Although difficult to answer, it is a question that, in the end, must be answered by the combined efforts of Government and industry.

Several constraints must be kept in mind by both parties. As mentioned previously, limited dollars will be available for acquiring defense systems so the user must eliminate nice to have features and question those which push the state of the art. Industry must provide proposals which trade off items considered unnecessary or offer a more effective method of accomplishing the task. In addition, we must

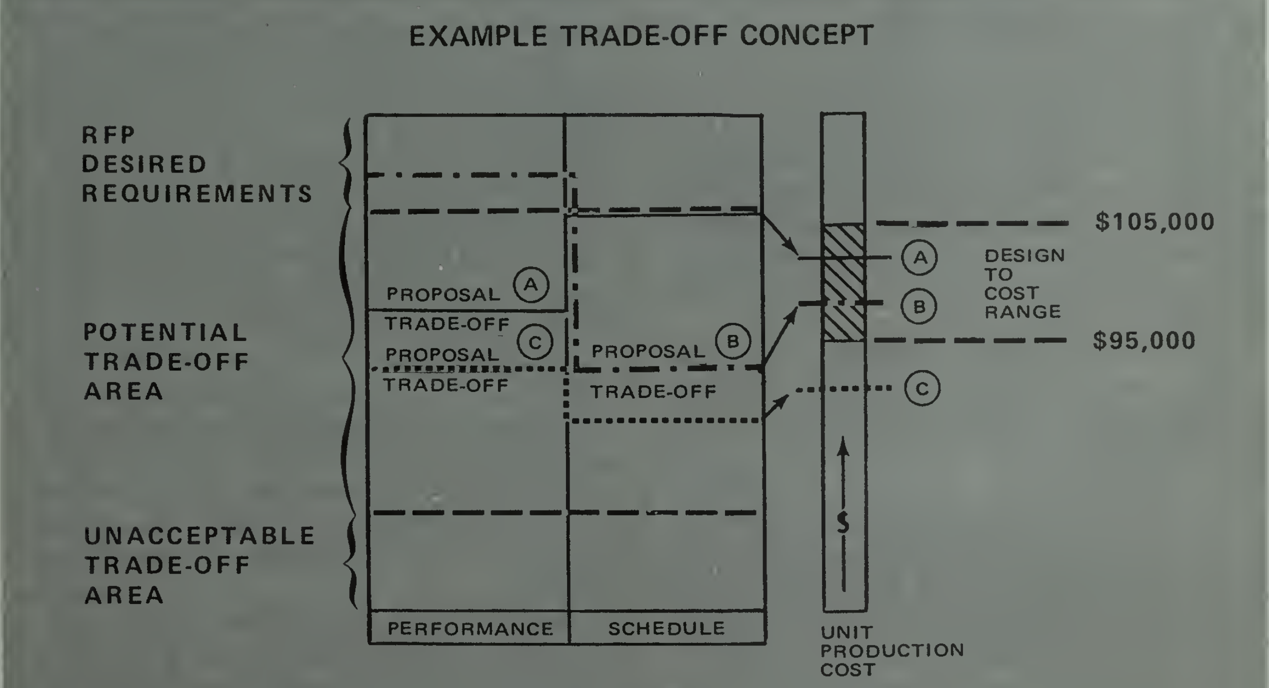


Figure 2

sharpen our cost estimating techniques, beginning with parametric cost estimating,* to help set the initial parameters. Finally, added to all of these efforts must be hard work, dedication and disciplined management.

There must be discipline on the part of the Government to designate performance and quality parameters which will permit the development of an acceptable item at a cost it can afford; and discipline on the part of industry to accept the challenge of developing an item which will fulfill the defense mission within the dollars Congress appropriates for it. Should either of us fail to accept that discipline, there will be no winner.

## New Army Acquisition Policies

The Department of the Army has now established six basic policies outlining the framework of the systems acquisition program. While these policies represent, to some extent, a reaffirmation of policies already in effect, they also reflect new policy on the acquisition process. The policies are all aimed at the realistic reduction of the cost of weapon systems acquisition and operation. Essentially they are:

- Shorten requirements generation time.
- Utilize high level decision making.
- Shorten development time.
- Observe funding priorities.
- Consider cost versus quantity.
- Exercise program cost control.

The area of shortened requirements generation time is primarily an in-house Army action to reduce the time between the origin of an idea and its establishment as a requirement, or its abandonment in favor of a better concept or a higher priority item.

Generally, new development efforts will start when a technological opportunity appears, when potential enemies are developing equipment superior to ours, or when there is a general consensus that equipment in the hands of troops will soon be obsolescent. This Army effort begins with the assembly of a special task force to prepare a detailed description of the proposed system and development plans for consideration and approval of the Army.

A realistic systems acquisition program for the Department of the Army involves high level decision making. The top managers of the Army participate in face-to-face decision making on major weapon systems development. The Army Systems Acquisition Review Council (ASARC) is the vehicle for such decisions. After the first ASARC meeting, the Army makes a maximum effort to assure the acquisition of the system within the shortest reasonable time.

In implementing the policy of shortened development time, the Army established six years as the target from the first ASARC meeting to initial operational capability (IOC), providing it can be accomplished without inordinate risks. In subdividing the overall time frame, the Army has established a target of less than six months from the first ASARC meeting to the contract award.

There is presently an increased emphasis on the development of new systems to take advantage of advanced technology. However, RDTE (Research, Development, Test and Engineering) appropriations are far from being unlimited. Within the RDTE appropriation, the Army must trade off low priority projects to permit full funding of top priority projects so development time is not lengthened. Recently, we have witnessed the termination of engineering feasibility study contracts for the Army Aerial Scout, while projects of higher priority like HLH (Heavy Lift Helicopter) and UTTAS (Utility Tactical Transport Aircraft System) have been funded.

The success of a program requires that the system acquisition meet technical performance objectives not only within a reasonable time frame but also within planned budgets. Excessive cost growth has been a major factor in the cancellation or cutback of some programs by the Office of the Secretary of Defense and Congress. Extreme care must be exercised to ensure that cost estimates realistically represent the cost of the system and that meaningful cost control over the acquisition process is maintained.

Control of cost, during development, must include consideration of the full cost effect of technical changes and whether or not additional expenditure will be returned, with interest, during the production and operational phases.

* *See "Parametric Cost Estimating Aids DOD in Systems Acquisition Decisions," by Donald W. Srull,* Defense Management Journal, *April 1972, p. 2.*

Program managers must be prepared to consider trade-offs involving performance within primary bands, secondary characteristics and related savings. They must also consider development schedules and production and operating cost trade-offs to assure the availability of a cost effective system for production.

### Contract Negotiation

Another practice being implemented at Army Aviation Systems Command (AVSCOM) is negotiation of contracts before selection of the winning contractors for major systems programs.

With Utility Tactical Transport Aircraft System contracts awarded in August 1972, AVSCOM implemented the practice of negotiating fully structured contracts with all offerors in the zone for consideration. Our plans for upcoming major programs are to conduct negotiations throughout the evaluation period. This will permit the preparation of contracts for all potential awardees. Proposed contracts signed by each contractor will then be available for presentation to the Source Selection Authority. Following his decision, the offer from the winning contractors need only be signed by the contracting officer to become an effective contract.

This process should improve negotiations. The evaluators from the Source Selection Evaluation Board are the most familiar with the weak and strong points of each proposal and the rationale for the rating. Negotiation during the evaluation permits these evaluators to participate and to present their positions to the offerors for resolution of each item.

### Design to Cost Incentive

The contract awarded for the development of a system will include an incentive provision to cause the contractor to keep the production cost spotlighted throughout the development program. An award fee, based on the contractor's progress toward achieving the established recurring production unit cost goal, is an appropriate incentive provision. The amount of the incentive fee must be sufficient, *i.e.*, it has to be large enough to really keep the attention of the contractor's top management on the achievement of the design to cost ceiling.

The whole thrust of the award fee incentive provision is to ensure the contractor is maintaining a dedicated effort to designing an item which will cost the Government no more than the design to cost goal stated in the contract. It also causes the Government to intensively evaluate and assess the estimated production cost of the item at regularly scheduled intervals during development. If the Government is convinced at a relatively early milestone in the development that the contractor's design is susceptible to meeting the unit production cost goal, an award of part of the "design to" award fee portion of the contract could be made. The first fee award could be up to 20 percent of the design to fee pool. Increasingly larger percentages would be available for award fee by the Government at consecutive milestones which provide greater assurance of the design producibility at the price established in the contract.

Another feature would be that any award fee not earned at periodic intervals could be carried forward for possible award at the conclusion of the development. It is the Government's desire the contractor achieve the production unit price which has been established.

I would be less than candid if I did not mention, however, the most significant portion of the award fee will not be available to the contractor until completion of the development. I believe an award of up to 50 percent of the total fee available under the design to provisions of the contract should be available for award at that time. This is the time the contractor assumes the real acid test by agreeing to a fixed price type contract for the initial production quantity.

### Failure To Achieve the Goal

There is one point I want to make clear. If the contractor fails to ultimately achieve the design to cost goal, he will jeopardize his contract and the entire program. The Army faces the same constraints when submitting a program for approval to the Secretary of Defense and is required under the ground rules to set forth the design to cost goal. This goal is then considered by the Secretary of Defense to determine whether or not the Defense Department can afford the system and whether or not the Army should be authorized to proceed with

its development. If the Army fails to develop and produce the item within the design to cost goal agreed to with the Secretary of Defense, it could result in program cancellation.

Under the design to cost and trade-off concepts, technical aspects and cost will be equally weighted. Within the cost area, priority is now given to the design to production unit cost and cost of operations over research and engineering cost. In other words, the Government is willing to pay a higher development cost if it achieves a more economical production unit cost and a lower cost of operation.

Although these concepts will be further refined as we gain experience, they are a significant step forward for the Army in reducing the cost of defense weapon systems. Thus, while there is continuing emphasis on obtaining a quality system technically, we are turning the spotlight toward cost. □

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**Every event that a man would master must be mounted on the run, and no man ever caught the reins of a thought except as it galloped past him.**

**—Oliver Wendell Holmes, Sr.**

# Design to Cost Application in Military Environment Means Changing Old Ways

Competition in the commercial avionics marketplace dictates the selling price of the various products. If the price is too high the products will not sell. The acceptability of a selling price is based on many factors, some of which are what competition offers, technical features that result in adequate performance in actual use, return of profit necessary for a company to remain in business and that the producing company will be held responsible for reliability performance in use.

Relating the experiences of the Collins Radio Co. in commercial avionics and comparing the design to cost concepts to possible DOD applications, four general areas will be explored in this article:

- Actual results of design to cost in the commercial market.
- Typical trade-off decisions necessary during the design cycle to hold down production costs.
- Electronic equipment procurement comparisons between the military and the air transport industry.


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Opinions expressed herein are those of the author and not necessarily those of the Department of Defense.


- Using the air transport industry as a model, presentation of some suggestions for applying similar techniques to military procurement, with concrete advantages to the military and industry.

The initial production cost goal must be established at the time of design concept by a structured group of design engineers and manufacturing specialists, including industrial engineers, quality, reliability, and component part engineers, value engineers, purchasing and cost tracking specialists. As the design concept evolves into later stages of development, there must be a continuous and scheduled monitoring of estimated production costs. When necessary, changes must be made to reflect required technical feature trade-offs, as well as revisions to simplify production or the use of fewer and cheaper parts.

## Some Actual Results

Figure 1 depicts actual results of production estimates for three avionic equipments. The dashed line represents estimates of production costs during the design cycle, while the large dot denotes the actual production cost at the present time. Reductions are expressed as a percentage of the concept goal.

Figure 2 provides an actual comparison of a commercial product and a military adaptation

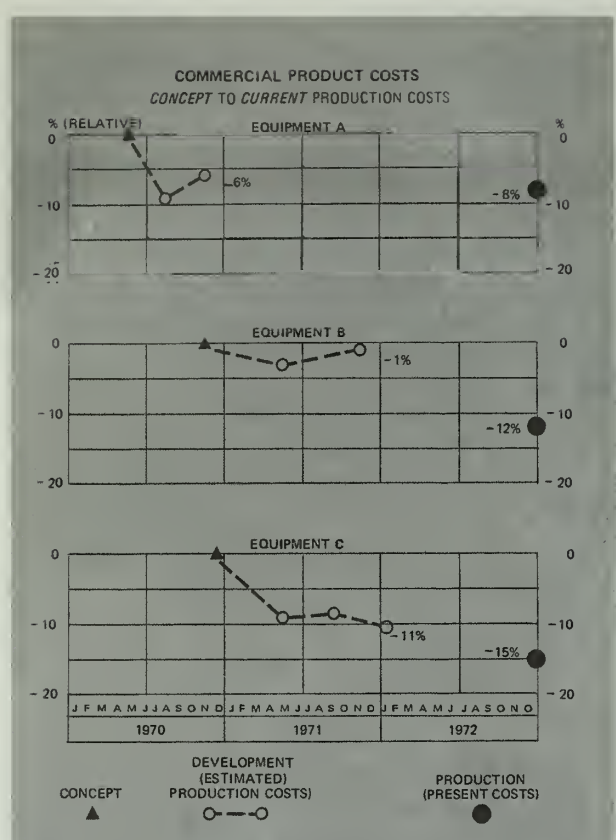


Figure 1

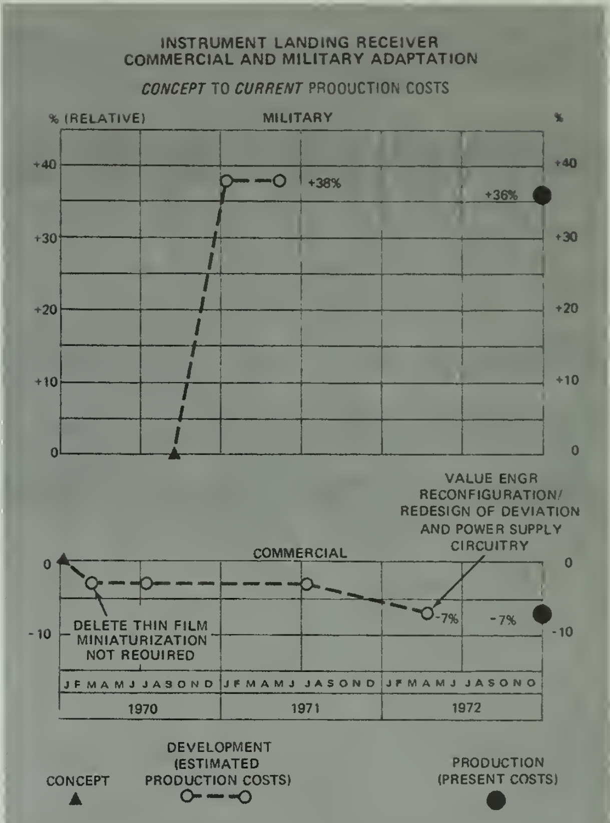


Figure 2

of an aircraft instrument landing receiver manufactured by Collins. This equipment was originally developed for commercial application for conditions during which the aircraft must land without visible contact with the runway. Therefore, the primary autoland characteristics are continuously monitored and the use of self-test circuitry is extensive. The obvious need for reliability demands the use of reliable parts which have been adequately derated for conservative application.

The equipment was adapted at a later date to a military application which dictated a more rugged packaging to meet tougher environmental specifications. Many of the monitoring and self-test capabilities were removed. Due to these differences from the commercial equivalent, a lower production rate resulted and the concept cost goals were set at 70 percent above the commercial version. By the end of the design cycle, the commercial version was 7 percent *under* its concept cost goal while the military version was 38 percent *over* its goal. Some reasons for the increased military cost were:

- Military specifications required that no more than three wires be attached to any terminal and front panel screws be painted to match the panel (the commercial version used stainless steel screws).
- Some feather edges in countersunk holes in the aluminum chassis would not meet military specifications.
- Military version required JAN–TX and ER parts which increase reliability but are more expensive and less available.

A primary concern, as shown in Figure 2, is that the original concept goals for production costs were 70 percent more for the military version than the commercial version and that the actual costs are considerably more.

## Trade-Off Decisions

There is greater freedom to act in the commercial world because of better knowledge of higher-order system requirements and improved direct communication between the designer and the end item user. This freedom permits more effective trade-off decisions, which result in reduced costs and improved reliability.

Some typical decisions applied to commercial products are:

- Reduction of the minimum power output requirement by 1.4 decibels which had an insignificant effect on performance. A lower-cost output transistor could now be used and the junction temperature was lowered, resulting in improved reliability.
- Change to a new type of integrated circuit resulting in elimination of several discrete parts and a complete multilayer board. Such a change to military equipment would have required non-standard part approval.
- Use of a lower-cost meter movement with a special low-scale calibration rather than a more complex servo system as originally conceived.

## Procurement Comparisons

In most military procurements, multiple users feed their requirements into an approval agency which, in turn, transmits them to a procurement and technical definition group. Definitive specifications are let to the contractors for bidding. There is little, if any, communication back to the user and almost no cost versus function trade-off considerations.

In the procurement route used by the air transport industry for electronic equipment, the users normally feed their system requirements to the Radio Technical Commission for Aeronautics (RTCA) where the users, industry and Government agencies, ultimately define the *minimum* system operational characteristics. Then specific equipment requirements are generated from these characteristics by Aeronautical Radio Incorporated (ARINC), an independent affiliation of the air carriers. Such requirements define the general functional characteristics, including form and fit, and are a joint determination of the users, industry and the Government.

While these general technical requirements are established through RTCA and ARINC, the cost versus specific function trade-offs are negotiated, individually and directly, between various users and industry. In this respect, the user considers initial and maintenance costs, operational characteristics and warranty conditions within the envelope requirements specified by ARINC. On a broad basis, the contractor's reputation for price, delivery and quality is very important to successful procurement.

## Suggestions for DOD Procurement

Recognizing the current differences in procurement methods and their applications, the importance of DOD enlarging its efforts to define and advance system requirements cannot be overemphasized. Both industry and the military need this information to make intelligent cost versus function trade-offs, such as RTCA provides in the air transport market. The following suggestions are offered as a basis for further consideration of alternative applications:

*Adopt a common form-fit concept* for standardization and enlargement of the military market for maximum stimulation of competition. To accomplish this, DOD would provide, in concert with industry, specific form and fit and generalized functional requirements by equipment type. Then the Military Departments, again in association with industry, would determine the specific equipment functions, as well as expected production cost targets. Any Military Department could utilize an equipment developed by another Department as the size, connectors and external wiring would be the same. An industry supplying one Department could produce for another Department, providing for an enlarged production base.

*Establish technical councils* comprised of users, military technical definition agencies and participating contractors. Divide council participation into three phases, with different membership for each. These phases would be:

- Phase 1—Definition of form and fit envelope by equipment type.
- Phase 2—Establishment of specific equipment requirements with production cost targets.
- Phase 3—Continuous review of cost versus performance trade-offs during the design cycle (including only contractors with specific contracts).

*Specific equipment requirements* should be classified into three distinct categories: essential, important, and desirable. *All* requirements would be susceptible to cost versus function trade-offs, as administered by the Phase 3 technical council already described. The reliability aspects of the end product must remain a primary consideration in trade-off decisions. In the example cited earlier, power output would usually be considered an essential requirement

and yet a reduction of 1.4 decibels could improve the equipment reliability to a point where that particular trade-off would be a very wise decision.

*Specifications* should be applied only as necessary and directly applicable, and *only* by reference to each paragraph number of the individual specification. This will eliminate the long-standing problem of automatic and expensive inclusion of subsidiary specifications. All specifications thus applied should be continuously reviewed during the design cycle for applicability and necessity, with no specifications to be applied during the production cycle which were not in force during the design cycle. As an example, two equipments of similar function, a military UHF transceiver and a commercial VHF transceiver are compared. For the commercial equipment, nine documents totally describe the needed requirements. For the military equipment, 44 documents are directly referenced (22 specifications, 17 standards, 5 publications) and one of the specifications (MIL–E–5400) references 408 specifications and standards through the next tier alone. These two equipments have the same basic mission, multifrequency, air-to-ground line-of-sight communications; however, the cost difference is about 6 to 1.

*Contractor responsibility for equipment performance after delivery* should be required by DOD. The air transport business, as mentioned earlier, relies heavily on the producer's reputation, and follow-on business provides the incentive to do a good job. DOD must find some method of providing the incentive to accomplish the same result. Since such incentives and responsibilities require more specific definition, the following is suggested:

- All equipments to be repaired by the contractor.
- Operational mean - time - between - failure (MTBF) to be contractually specified.
- Cost of repair actions to be negotiated, considering verified failures and unverified returns.
- Negotiate the expected number of equipments to be returned based on MTBF calculations and considering unverified failures.
- Provide for Government verification of equipment which is obviously beyond repair, such as burned-up, run over by a truck, etc.
- Each month send the contractor the calculated dollars for expected returns, assuming that the contractual MTBF is being met.
- The contractor, in turn, absorbs excess failure costs or profits when equipment performs better than the specified MTBF.

## Summary

Electronic equipment *can* be designed to cost. However, contractors must have greater freedom of action by being able to make trade-off decisions. The overall system parameters must be known if the proper trade-offs are to be made, but further dialog is necessary between industry and DOD to utilize these suggestions in the military environment. □

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**Training is everything. The peach was once a bitter almond; cauliflower is nothing but cabbage with a college education.**
**—Mark Twain**

# Designing to Low Ownership Cost Requires Knowledge of Many Factors

Ownership cost as distinguished from price indicates all costs the Government incurs from the initial decision to proceed toward acquisition of a defense system throughout the operational life of the system.

Current emphasis of the Defense Department on designing to an ownership cost requires sound knowledge of the customer and product, and systematic trade-offs between the effort expended in design and development and the expected resultant savings in operation. An appropriately motivated and informed design team can contribute more to a balanced design than a bushel of trade-off studies, but with complex technology and only partial knowledge of the customer's environment, emphasis on cost reduction in any single area does not always yield reduction in overall ownership cost. For example, attempting to reduce the number of flight line and base level maintenance man-hours required to service an unreliable radar transmitter by packaging the transmitter as an individual LRU (line replaceable unit) and repairing only at a depot ignores the long pipeline of spare transmitter LRUs stretching from depot to base. On the other hand, the cost of the spares pipeline may be cheaper than the personnel training cost required to keep qualified radar repair technicians at each base. The most desirable action would be to improve transmitter reliability but research, development and test costs may outweigh projected operating savings. Thus designing to an ownership cost involves knowing which factors make a cost difference, which factors the contractor can control, and the manner in which expenditures or design changes in one area affect performance and costs in other areas.

Current cost trade-offs use marginal or direct cost factors rather than full ownership cost factors. As a result, even when reliability and maintainability trade-offs accomplished during system development show the value of increased development efforts to improve supportability, rarely are additional funds expended to acquire a supportable system. This is explained by the different types of funds involved, the uncertainty of future savings, and the *relatively* small support cost savings the marginal cost analysis indicates.

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Opinions expressed herein are those of the author and not necessarily those of the Department of Defense.

## Measuring and Computing Ownership Cost

Ownership costs include RDT&E, investment, and operating and support costs. A representative breakout of these costs includes:

- *Subsystem Design and Development:* Test set production (manufacturing labor, manufacturing materials, sustaining engineering), test operations, support and evaluation.
- *Investment Costs:* Facilities; primary mission equipment (labor, materials, sustain-

ing rate tooling, sustaining engineering); unit support; maintenance ground equipment (MGE); initial supply and spares inventories; initial personnel training, travel and transportation.

- *Operating and Support Costs:* Initial and replacement spares; on and off equipment maintenance; inventory entry and supply management; support equipment; personnel training and training equipment; management and technical data and new facilities.

Many models are available to compute operating and support costs. The Air Force Logistics Command Logistics Support Cost Model is used here to illustrate a comprehensive framework for support cost computation. Each equation is basically of the form:

COST = OPERATING HOURS × FAILURES OR MAINTENANCE ACTIONS REQUIRED PER OPERATING HOUR × PARTICULAR COST OF A FAILURE OR MAINTENANCE ACTION

There are a large number of factors included in this model. Required data can be characterized as LRU-related elements (contractor estimates), subsystem elements (contractor estimates), program elements (Government and contractor estimates) and standard cost elements (Government furnished).

Given such models, the validity of available data and the applicability of test results obtained in the development environment become important issues. In practical cases involving avionic systems the equipment related elements that drive costs are field reliability and necessary maintenance actions (mean flying time between maintenance actions), LRU unit costs, required maintenance ground equipment and number of new parts.

## Designing to an Ownership Cost

To achieve a low ownership cost, credible indications of high support cost areas must be available as well as estimating methods to relate development and acquisition costs to equipment characteristics. Related field performance information and available trade-offs must be presented in a lucid form so designers and development engineers can understand the situation. Cost trade-offs during system conceptual and validation phases can only be at a gross parametric level. The most significant support costs are program related (basing, dispersal, maintenance posture, operating program), and very few costs can be design related during these early phases. If new technology is required, estimates may be made of new facilities and new types of training required, but statements about spares will be only approximate.

Prototype production is the first point at which *accurate* system level logistics and support cost estimates can be made. Some trade-offs, such as the extent of test equipment versus maintenance hours, reliability growth program costs versus spares requirements, and maintenance man-hours per flying hour versus transportation and inventory cost to maintain spares pipelines, are still possible at this point. While some redesign is possible, its cost increases as the level of certainty increases. Once a basic design is selected, trade-off analyses are limited to changes in quality of parts, inclusion of redundancy, control of production tolerance and reliability goals for particular parts or components, and choice of production methods. For this reason it is important that initial design analyses focus on estimated high production and support cost elements and seek alternatives to reduce them.

Modifications to traditional project management and engineering review procedures are indicated. Logistics planning, cost analysis and production planning typically tend to occur apart from the mainstream design process. If costs are to be a real consideration, specialists should be present throughout the design stage and at design reviews.

## Review Process

In some cases, formation of a cost of ownership team can be useful to participate in the on-going design and development process. A team may include:

- *Value Engineer and Team Leader* to examine the overall design and development process, seek out high cost areas and coordinate the efforts of other specialists.
- *Production Analyst* to assess the manufacturing and fabrication implications of different designs, and generate production information from which costs can be obtained.
- *Reliability Engineer* to derive reliability estimates of system components, and suggest

methods of attaining reliability goals.

• *Maintainability Engineer* to analyze each design for ease of maintenance, derive repair times and repair methods, and perform BITE/MGE (Built in Test Equipment/Maintenance Ground Equipment) trade-offs.

• *Procurement Specialists* to quote parts and component prices for items procured from vendors.

• *Design Engineer* to assess the engineering feasibility, at the circuit and component level, of changes discussed by the team.

• *System Engineer* to assess design progress and potential alternatives in light of the overall system performance goals and major functional interrelations.

One such system development is illustrated in Figure 1. General performance goals are assigned early to individual LRUs. Review

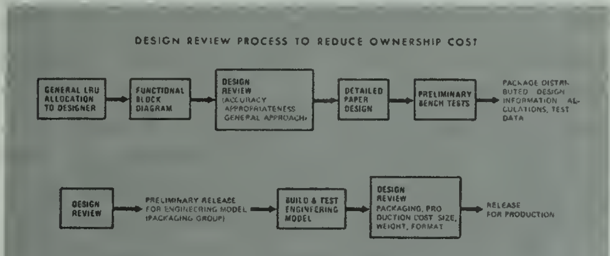


Figure 1

points occur for each LRU and, to ensure design balance, team members are in day to day contact with the design engineers. The team is included in each design review. Based on knowledge gained through contact with the designers, and through the use of simple estimating tools, the team possesses estimates of subsystem and component performance, reliability, maintainability, producibility and associated costs. It then can determine and supply the program manager with information on the degree to which various LRU goals are off initial targets.

Separate from the individual design reviews, the team leader continually searches out areas of high fabrication, test and support cost. As these are discovered, system and design engineers are asked to generate alternatives to reduce costs, assess whether the proposed changes are feasible and estimate their effect on overall performance.

## RDT&E Cost Estimates

Early RDT&E cost estimates are required for this process. Unfortunately such cost estimates have been incorrect with discouraging regularity. Electronics equipment presents a particular problem since intense technological advance continues. A modern airborne radar may bear no more relationship to the airborne radar of a decade ago than the name.

One promising RDT&E cost estimating approach relates costs to measurements of technology advance over time. The technological advance required by a given equipment is estimated. Using a trend line of technology advance developed from a data base of roughly similar equipments over time, the advance sought by the new project and the development time allotted yield a probability of success and an estimated development cost. "A*" in Figure 2 represents technical advance sought in a program. Given that it falls outside the normal distribution of program outcomes (shaded area), a prudent program manager will seek alternatives.

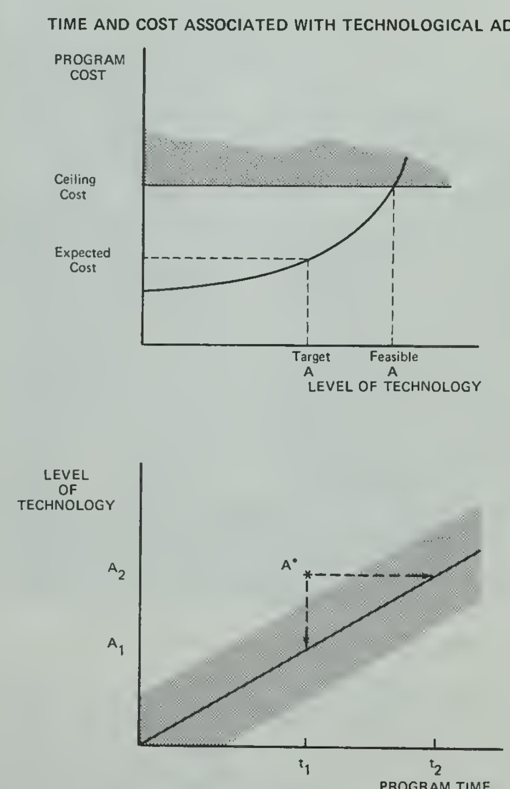


Figure 2

## Production Cost Information

Fabrication costs can be reduced if design and development engineers know how contemplated design changes will affect cost. It may be possible to identify production methods which both improve the product *and* reduce production cost. Labor is the principal component of development and production cost, and use of automation versus labor (wiring machines, automatic soldering, conveyor lines) may be profitable. Other avenues of investigation should include increasing reliability by use of proven components, extended test and checkout during production, and planned reliability growth programs. Support cost reductions can be sought through reduced training and technical data costs, reduced new item entry and management costs, and sharing AGE (Automatic Ground Equipment) costs by extending the capabilities of previously proven designs rather than designing anew.

Simple to use prepared forms and models which can be run close to the engineer to evaluate such design changes are useful. Examples include:

- *Cost models* which simply aggregate parts type and number used in a circuit or equipment to overall cost. This requires only a standard parts list with parts cost included so the design engineer checks off the parts and numbers used in that component.
- *Reliability models* which generate overall equipment failure rates given individual component failure data. The engineer checks off the components he is using and one of several configurations. Overall failure rates are then computed.
- *Fabrication cost models* which compute costs given type of production (weldment, riveting, built up assemblies, etc.) and standard time, material and methods costs.

Such straightforward models can be programmed on a variety of desk calculators and sub-minicomputers to yield information in minutes rather than days.

## Performing Trade-offs

The contractor must determine the degree to which each equipment and system related variable affects cost of ownership—a sensitivity analysis. This allows effort to be allocated appropriately. Equal attention need not be expended on all cost generating variables in a support cost model. Only those characteristics that generate the largest costs and over which the contractor has control should be carefully analyzed to find alternatives. Ownership costs are generally quite sensitive to reliability, unit cost, maintenance *concept* (not mean time to repair), number of new parts introduced, maintenance ground equipment requirements, and support policies (depot and base cycle times).

## Trade-offs with Full Cost Factors

Functions such as spares procurement, management, distribution, technician training and maintenance test equipment can be related to ownership of specific categories of equipment. But very significant *indirect* costs are also generated by military systems. These costs include some portion of the maintenance base (depots, shipyards, repair ships and tenders); the training establishment; and the defense administrative infrastructure (data processing and communication activities, and base and headquarters support personnel and facilities).

If full costs of systems ownership were available, trade-offs between equipment characteristics and full ownership costs would indicate the significant resource impacts of reliable and supportable equipment. The costs depicted by curve I in Figure 3 include only direct and marginal cost elements such as maintenance manpower and spares. System costs do not reflect the existence of such facilities as depots

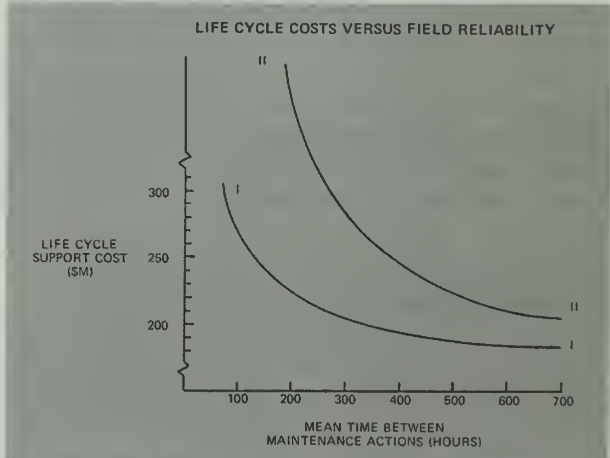


**Figure 3**

*(please turn to page 61, col. 1)*

*An Appraisal*

# Evaluating Indirect Costs Through the PIECOST Approach

PIECOST (Probability of Incurring Estimated Cost) represents a quantitative approach for assessing the reasonableness of a defense contractor's planned indirect costs necessary for future contract performance. It is currently being applied by the Department of Defense, with the Air Force serving as executive agent and program monitor.

In April 1970, the TRW Systems Group was selected as one of six contractors to participate in a Phase I test of PIECOST. In the TRW test application, it was observed there are five considerations of critical consequence which can affect the results of this analysis, and each must be resolved early in any application since it can influence the reliability of the final conclusions.

PIECOST uses straight line regression analysis as its basic statistical component to determine the average relationship between categories of indirect cost (Cost Modes—the dependent variables) and those factors that influence indirect cost incurrence (Drivers—the independent variables). It consists of 12 separate linear equations, one for each Cost Mode, used to project a future year's indirect cost. Figure 1 shows an example of regression analysis as used in PIECOST.

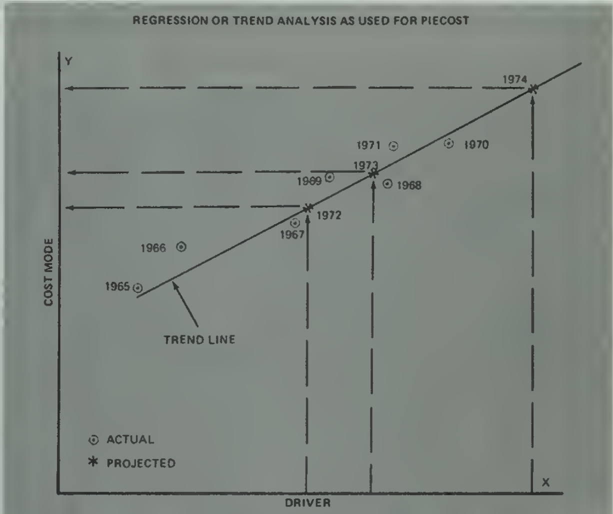


Figure 1


by Carmen F. Gullo
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and

Lyle N. Whited
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Opinions expressed herein are those of the authors and not necessarily those of the Department of Defense

## Indirect Cost Mode Categories

The first area of consideration involves indirect cost categories. PIECOST requires that a company summarize its indirect costs into 12 categories or Cost Modes (Figure 2) for purposes of analysis. This process defines specifically the indirect costs by cost account to be identified in each Cost Mode.

Most contractors will find a conceptual similarity between PIECOST Cost Modes and their own internal categorization of cost accounts for internal management purposes. However, differences between customer and contractor can arise in the resolution of a company's forward pricing proposal when a Government agency uses the specific Cost Modes prescribed by PIECOST to project a firm's indirect costs, while the contractor's own internal management and planning process uses different cost groupings. Contractors customarily use the same classification system in indirect cost proposals as in their budgeting, administrative control and collection of costs.

This concern can best be resolved through the use of the contractor's cost categories when they are as reasonable and meaningful as the PIECOST Cost Modes. Allowing the contractor to use his cost groupings for planning, budgeting, reporting and controlling indirect costs seems to be most cost effective and eliminates the necessity for the contractor to revise his internal systems or to continually develop reconciling data between the two different cost groupings.

A standardized modal system, if used by all contractors, would not permit an across the board contractor comparison of indirect costs with negotiated overhead rates. Such a comparison would be misleading since there are fundamental product mix differences among contractors, and contractor charging practices vary greatly. A uniform Cost Mode system is insufficient in itself to give meaningful comparisons of various contractors' indirect costs.

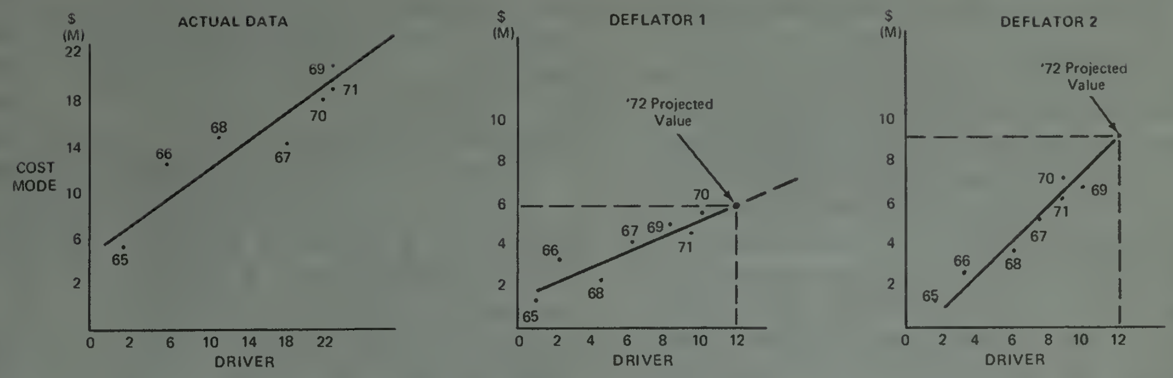
The usefulness of PIECOST as one tool for evaluation of projected costs would not be undermined by adoption of the contractor's cost account classification system, but would allow for an active communication between customer and contractor in the analysis of costs. Tailoring the Cost Modes to the classification structure of the individual contractor would eliminate a reduction process of the firm's management to a new set of cost relationships and would remove any requirement for the contractor to physically realign his internal accounting, budgeting and reporting system to be consistent with specific PIECOST Cost Modes.

### Cost Mode, Driver and Index of Determination

| Cost Mode (Dependent Variable) | Driver (Independent Variable) | Index of Determination (Percent) |
|---|---|---|
| Indirect Labor | Indirect Labor Hours | .99 |
| Employee Benefits | Total Labor Dollars | .98 |
| Payroll Taxes | Total Labor Dollars | .99 |
| Employment | New Hires | .99 |
| Communication/Travel | Office/Clerical | .99 |
| Production Related | Direct Labor Hours | .92 |
| Facilities—Buildings | Square Feet | .98 |
| Facilities—Equipment | Square Feet | .98 |
| Administrative | Sales Dollars | .99 |
| Future Business | Next Year's Sales Dollars | .85 |
| Other Miscellaneous | Sales Dollars | .81 |
| Credits | (Not Regressed) | |

Figure 2

EFFECTS OF DEFLATOR SELECTION




| Deflated Projection | 1972 | Projection Price Deflator* | Current Dollar Projection |
|---|---|---|---|
| 1 | $6.0 M | 150.0% | $ 9.0 M |
| 2 | $9.0 M | 150.0% | $ 13.5 M |

* Price Deflators are used to inflate projected indirect costs, which are in constant dollars.

**Figure 3**

## Development of Price Deflators

Through the use of price deflators [1] in the PIECOST process, the effects of yearly inflation on cost data are eliminated. While it is important to focus on these effects, there is an area of concern in the development of price deflators.

It is important to recognize that indices used to deflate historical data can greatly affect the regression analysis projection by changing the slope of the regression line, thereby seriously affecting the final outcome of the regression analysis (Figure 3). With a reasonable amount of research, price deflators can be approximated to deflate a firm's historical data for most of the Cost Modes and Drivers expressed in dollars.

[1] *A price deflator is an index number used to equate all costs to a base year, e.g., 100% = 1965. This compensates for the effect of inflation over a time period and permits a separate examination and evaluation of the forecasted inflation. With PIECOST, deflators are applied to historical data, the Cost Modes and the Drivers. The deflated cost data is then used in the regression equations. In a prospective sense, the deflators (index numbers) are used to inflate the projected indirect costs, which have been forecasted in constant dollars. These reinflated projected indirect costs are then used by Government representatives to evaluate the contractor's planned indirect costs which support his forward pricing rates.*

The formulation of deflators for future years, to satisfy the reinflation process in PIECOST, is more difficult since the future rate of inflation in the economy must be considered. Some questions to be answered are: How will union negotiated wage and benefit settlements impact a firm's costs? What price will aerospace skills demand in the marketplace that will exist? Management can influence the rate of inflation in a firm within some limits, but exogenous factors are also at work.

It is in this uncertain environment that forward price deflators must be developed for the PIECOST process. If projected deflators are understated, the projected overhead costs that are reinflated to current dollars will be too low; thus transforming the Cost Mode projections into forward pricing rates will produce lower rates than are actually attainable.

A second order question, related to the development of deflators, concerns the determination of those changes in costs which are not due to cost inflation. This question is of particular concern when regional or national deflators are used. For example, the rate which a company pays for medical insurance is subject to change for a number of reasons, including:

- Claims experience.

• Demographic nature of the personnel covered.
• Coverage provided by the insurance plan.

### Selection of Drivers

The identification of Drivers (independent variables) is the third area of PIECOST which requires careful consideration. Drivers are factors that influence the incurrence of overhead costs and their use brings a dimension to the development and evaluation of overhead proposals that is sometimes lacking. In its use of Drivers, PIECOST focuses attention of evaluators on sets of statistical relationships for appraisal of proposed overhead expenditures. Many firms and Government agencies, such as the Defense Contract Audit Agency, have used this type of analysis in indirect cost evaluation.

In selecting Drivers to be matched with each Cost Mode, PIECOST uses the Index of Determination ($R^2$) as the statistical measure of correlation. The closer $R^2$ is to 100 percent, the closer the Driver reflects the historical fluctuations in the Cost Mode. However, in addition to having a high index of correlation, the Driver chosen should have a valid and logical relationship to fluctuations of the Cost Mode. For example, in a test case, pairing the Driver (DOD expenditures) with the Cost Mode (indirect labor) resulted in 99-percent index of determination. Although there is a high $R^2$ and statistically this Driver would have worked well in the past, it does not reveal how it will work in the future, and it is doubtful that it affords a sound basis for projecting future years' indirect labor costs or explaining satisfactory prior year incurred costs. Judgment and an understanding of future causal relationships must play an important part in the selection of a Driver.

In the initial PIECOST research, over 400 Drivers were reviewed in search of those factors that influence indirect cost incurrence. Currently, as with the original PIECOST research, only one Driver is used in the analysis and projection of any one Cost Mode. During the Phase I review of PIECOST, both the Government agencies and the TRW Systems Group were able to demonstrate that more than one Driver could be selected for use. Each was statistically valid and logically sound, yet grossly different results were achieved. One Driver seems to be insufficient to adequately pinpoint an area of indirect cost incurrence, thus reliance on one Driver relinquishes the evaluative responsibility to a single statistical approach.

### Regression Analysis

Use of the regression equation in PIECOST is the fourth area of critical study. Regression analysis as a statistical measuring, sampling and forecasting device is an obvious asset to the analysis of cost trends as it gives a more favorable arena for the exposure of cost anomalies. However, the use of the regression equation must be tempered by judgment in its ultimate application and recognition of the shortcomings inherent in this statistical estimating technique. The regression approach is useful for projecting an approximate area in which an expected value will probably occur. Integral to every regression projection is the implied assumption that a probability of the actual value will be plus or minus from the mean calculated dependent value. This probability expressed as a confidence interval, or band of values on each side of the mean forecasted value, should be used to bracket the area in which the projected expenditure should be expected to occur (Figure 4).

The objective which the PIECOST process can satisfy is to identify the cost area in which

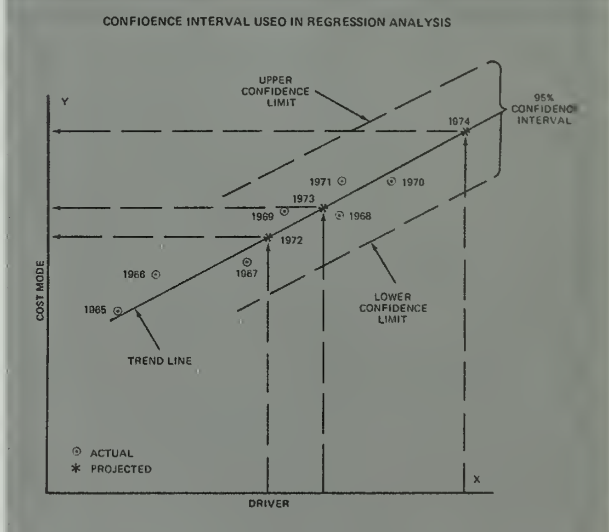



Figure 4

Government negotiators should find the contractor's overhead cost projection.

The regression estimate should be another yardstick to be used in the evaluator's detailed review of the overhead proposal. This fact becomes more apparent when the following shortcomings inherent in regression/trend analysis are explored:

- Regression analysis gives equal weighting to all historical data points. The most recent year's cost experience is weighted as equally as are costs incurred in the distant past. Actually there are many things difficult to measure or only broadly measurable in mathematical terms. Management emphasis changes. The dynamics of the business climate and its pressure cause change. Quality improvement, economies in operation, interpretation of a corporation's policies in a more stringent manner, and learning improvements cause cost patterns to change. Government regulatory changes can impose additional costs on a firm. With these dynamics in the cost environment that are not tied to inflation and not capable of precise measurement, it can be seen that a regression projection should only be used to determine the most likely area of cost incurrence. The cost patterns a company achieves in the most recent time periods (one, two or three years) are more salient in a planning sense than cost experience from an earlier period. The earlier periods, of course, should not be discounted, but management must maintain a prospective view in cost planning. Management direction determines in which areas funds should be allocated and this sometimes causes change in cost patterns. A weighting technique appears to be appropriate. Yet, in determining the proper weighting, another value judgment is injected into the statistical process. It becomes apparent that the strengths in PIECOST are in its application as an analytical tool to gauge the relevance of a contractor's overhead proposal and not as a method of pinpointing an exact Cost Mode value.

- There are limitations to the use of the calculated mean value from the regression estimate to negotiate a forward pricing agreement. To expect to negotiate an exact point value projected from a trend line which represents an average of past performance is not appropriate. The overhead proposal which is developed through a detailed planning process and presented to a Government agency for evaluation will, at best, have cost projections by cost category that approximate previous regression trends, but most certainly these costs will not equate exactly to the mean value projected by PIECOST. Pure chance or a forced estimate would be the only reasons why a company's internal planning would yield a projection by cost category or Cost Mode that exactly matched the mean projected value. In forecasting costs, a company should not relinquish a good internal planning procedure or let it be subservient to a statistical process that can only test the reasonableness of a company's current planning process in relation to adjusted or unadjusted historical trends. The process of adjustment of historical data, of course, opens up a new series of concerns and considerations.

- Currently, the PIECOST process uses only straight line regression. Curvilinear and multiple regression can assist in more closely focusing on changing cost patterns. Research performed by TRW Systems during the Phase I PIECOST review has shown that curvilinear analysis can allow for a closer approximation of projected cost patterns, and a smaller confidence interval tolerance can be calculated. Even the adoption of this refinement, however, will not overcome the basic weakness of relying on single point estimates.

For the foregoing reasons, regression analysis fulfills its correct function when it is used as a gauge or guide in the evaluation process. Air Force evaluators are aware of some of these regression concerns. They are appraising the use of confidence intervals and are considering other forms of regression, such as multiple and dynamic regressions,[2] to improve the actual usefulness of this statistical modeling device.

## Contractor Familiarization

The final area of concern which should be addressed prior to applying PIECOST relates to the need for complete contractor understanding of the process. In this regard, a two-week PIECOST training course has been established by the Air Force at Lowry AFB, Colo., to

[2] *Form of regression using exponential smoothing being developed by Air Force Academy PIECOST team.*

instruct Government personnel in the implementation of the process. Also, computer systems to handle contractor cost data and perform statistical analysis have been developed. Although the Air Force, as executive agent in this process, has been active in presenting abbreviated contractor seminars, workshops and briefings, there is a need for contractor personnel to attend the two-week training course and be given access to the currently developed computer systems. Contractor attendance at the training course would provide a deeper understanding of the PIECOST principles and facilitate increased communications between the customer and contractor, and access to the software computer routines that are presently available would serve to minimize duplication of contractor programming effort.

## Conclusions

PIECOST can be a useful analytical tool for developing a determinate model of a contractor. The use of mathematical models as an aid in performing the planning and control functions is desirable, although limitations of such models should be recognized. As with any model, the conclusions drawn are as good as the original assumptions.

It can be concluded from the foregoing that the PIECOST process requires careful implementation if it is to attain its objective. The cost projections generated by PIECOST can fill a need which has existed to assist Government representatives who must evaluate the reasonableness and accuracy of a contractor's planned costs. With the use of the PIECOST modeling technique, the Government evaluator, either on his own or in cooperation with the contractor, can generate an independent cost projection based on the contractor's past performance. If the contractor's planned costs are within the confidence interval of the projected costs, the evaluator has increased certitude with regard to their correctness. If they fall outside of this confidence interval, he has a basis for requesting a detailed explanation.

PIECOST is not a replacement for the analytical activities currently performed by Defense Contract Administration Services and Defense Contract Audit Agency personnel in their review and evaluation of a contractor's forward pricing rate proposal. However, it should shorten the required time by providing a means for highlighting those Cost Modes which show a changing level of incurrence. Maximum attention can thus be directed immediately to the Cost Modes to be questioned.

The contractor could find PIECOST useful in much the same manner, since it develops an independent cost projection which can be used to assess the results of internal planning and to calibrate the cost effect of future changes. PIECOST, while not a substitute for projected costs developed by a contractor's planning system, can serve as a yardstick for measuring change and its effect on cost. It may also serve as a basis for evaluating the adequacy of the planning system and for determining areas of possible weakness. Improvements to the planning system can then be made which will strengthen these areas and improve the quality of future plans. □

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**It is a tie between men to have read the same book.**
**—Ralph Waldo Emerson**

## NAVMAT Goal

# *Happiness Is Quality and Cost Effectiveness*

If any large enterprise is to have some assurance of success, the actions of its components must reflect adherence to a central objective or goal. For the Naval Material Command (NAVMAT) that goal is more efficient support of the Fleet.

Each member of the NAVMAT, from its top commanders to its most remotely situated employees, must work toward that goal, if we are to do the job of supporting, building, maintaining and replenishing the Fleet. Yet, no matter how dedicated, the people of the Naval Material Command and of the Department of Defense as a whole cannot do the job by themselves. They must act in partnership with the defense industry and, to some extent, the defense industry must share their goal.

During the Spanish-American War, Colonel Theodore Roosevelt is reported to have sent word from Cuba that, "There is enough glory for all in this business of ours." To fit our present situation, that sentiment could be amended to say, "There is enough burden for all in this business of ours." Certainly there is some basis for industry's criticism of the military's way of doing business. At the same time, DOD managers are sometimes justified in their complaints regarding industrial shortcomings. All of us have made mistakes in the past and are likely to make errors in the future. However, the key to success in the future is that DOD and industry must work as a team. We must unite to work together for the best interest of our Nation.

**by Admiral I. C. Kidd Jr., USN**
***Chief of Naval Material***

### Basic Areas of Concern

In this regard there are five basic areas which we should consider together. The first of these is the improvement of our credibility before the public and our credibility before Congress. Credibility can be achieved principally through the exercise of collective conservatism—conservatism in our estimates, conservatism in our agreements with each other, conservatism in resisting "gold-plating," and conservatism in promises of performance, price and delivery schedules. If we can progress to the point of fulfilling these conditions, we shall establish credibility not only with the public and Congress but also, incidentally, with each other. As a consequence of an aura of conservatism and thus credibility, we will find a greater willingness within the Congress to provide the necessary dollars to buy what we need to do our job for the taxpayers.

A second area to be considered is the competition we face. We must not allow ourselves to underestimate its strength. A few months ago a leading periodical told us, ". . . The U.S. has a much younger and larger surface fleet—one and a half times the size of the Soviet Fleet. . . ." As one who has been in a position to see so much of the Soviet fleet, seven days a week, my only comment on such a remark would be, I wish it were true. The U.S. Navy was disparaged in somewhat the same way at one time. In a newspaper headline it was described as a "company of ill-trained convicts and bastards sailing under a bit of red bunting in archaic ships of the day." That headline appeared in the *London Times* in 1812. Of course, we won that war.

A third area is the potential of foreign industry. Several months ago the Naval Material Command hosted the first International Conference of Directors and Chiefs of Naval Material. Held at the U.S. Naval Academy, the atmosphere for this first meeting was both cordial and optimistic, and plans were laid for more such meetings. It was a pleasure to note that the outlook of the foreign participants was one of mutual cooperation. This is the type of teamwork we must cultivate, and it is rewarding to see our allies moving in this direction. Both U.S. military and industrial communities must make an effort to assess the capabilities of foreign industry in similar fields. There are many foreign developments that could prove most helpful to U.S. programs. STOL/VTOL aircraft and surface effect ships are examples of two fields of technology with dynamic futures in which other nations are at least equal to, if not superior to, U.S. state of the art.

## Battle of Red Tape

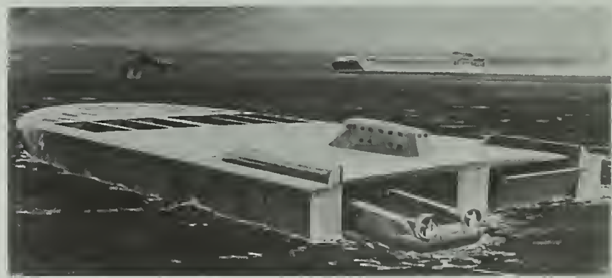
The fourth consideration concerns two basic problems in the production area which we must conquer if we are to consistently accomplish satisfactory results. First we must wage a real battle against Government red tape. A single example will illustrate the point.

In the Mark 48 Torpedo Project an urgent need developed for a modification kit. The requirement was given a top priority designation but then this priority request was placed in our standard operating system. The result can be guessed. It took four months on an expedited "rush" basis to get from a procurement request to a letter contract. During that time the request was subjected to at least 150 control, review and approval points within 74 organizational elements at eight different management levels.

Somehow, someway, we simply must do better than that. Proper control is essential,

Observing Soviet ships in Mediterranean.

Admiral Kidd meets with French Oceanographer Jacques Cousteau at First International Conference of Directors and Chiefs of Naval Material.



Artist's concept of surface effect ship.

but surely there is no absolute necessity for 150 checks on a single request for a letter contract, all before the contract is signed. When the number of checks made after award of the contract is added, the mind boggles.

### Complex Design in Equipment

Another production related problem is the complexity we are designing into our equipment. We must come down from the clouds in producing gear for the Fleet. It is a favorite alibi these days that the breakdown of equipment is attributable to incapable operators. However, let us face the facts. Rhodes scholars and PhDs do not often enlist in the Navy. Most young men sign up to secure technical training and not to exploit what they have already learned in civilian life.

The Soviets apparently understand and accept this state of affairs. The unit type of equipment they have been able to build appears to be tamper-proof. We must be able to do the same thing. If we, industry and the Navy in partnership, can no longer produce gear that is reliable to the point where the average "blue jacket," airman, or soldier of today can maintain and operate it, then we are all in the wrong profession.

### Innovation Needed

The final area which must be mentioned here for mutual consideration is innovation. The old ways of doing things are no longer good enough to meet the current budgeting and technical stresses placed upon us. We must seek out and implement new ways that will provide us with the efficiency and economy we need. We cannot be content with looking inward at our own organization for the evolution of new ideas. We must examine the accomplishments of others, even in seemingly unrelated fields, and seek to form them to our own advantage.

As an example, favorable reports from the Rockwell International organization indicate that it has been able to reduce overall cost by applying various cost cutting techniques common to the automotive industry. If this move is practicable and can be applied to weapon systems procurement, it may represent considerable opportunity.

### CURV III

There is no doubt that innovations can also come from within Navy internal organizations. Several of our present projects justify such optimism. An example that comes immediately to mind is the Cable-Controlled Unmanned Recovery Vehicle (CURV III).

CURV III is an advanced development project that progressed immediately into service use. Begun in FY 1968, this system extends our search and recovery capability to a depth of 7,000 feet in the sea. Development and evaluation testing was programmed for completion by July 1, 1970, within a cost of $4 million. The program was completed within schedule and cost targets and, during tests in 1970, demonstrated that it had met its requirements. Equipped with sonars and television cameras and highly maneuverable near the ocean floor at designed depths, it has almost unlimited endurance since its required power is transmitted by cable from the tending ship.

While CURV III was undergoing test and evaluation operations off the Southern California coast in early 1970, an emergency request was received from NASA by the Naval Undersea Center, San Diego, asking that the Navy attempt recovery of a rocket launched instrument package on the ocean floor about 100 miles east of Wallops Island, Va. It was decided to meet NASA's request by continuing the test and evaluation operations of the system in a search and recovery of the rocket package.

CURV III was flown to Virginia and deployed at sea to attempt recovery. Despite the fact that its acoustic pinger had already expired, the instrument package was detected by CURV's active acoustic equipment, identified by its television system, and then recovered, thereby preserving stored data pertaining to solar eclipse measurements. Detection and recovery were accomplished in 5,800 feet of water and achieved prior to the July 1, 1970, date for completion of system development and test.

An interesting aspect of this project was the fact that most of the system hardware was developed in-house at the Naval Undersea Center, San Diego, with contractor assistance where economically advantageous. Further-

more, all the specifications for performance and the standards for form, fit and function were developed within the Naval Ordnance Systems Command.

## Harpoon Program

Another example that could be cited is the Harpoon Program which is now in the engineering design phase and approaching the systems development phase. Initiated in late 1967 to satisfy the first specific operational requirement for an air/ship launched anti-ship missile, the project is a cost effective program. Orderly development, which was of paramount importance in establishing a framework for the program, was to be accomplished in four phases: validation, design, weapon systems development, and operational deployment. The use of phases in system acquisitions permits decisions regarding future work to be made as late as possible and requires the resolution of risk areas and the completion of milestones prior to commitment of funds for work to be accomplished in the next phase.

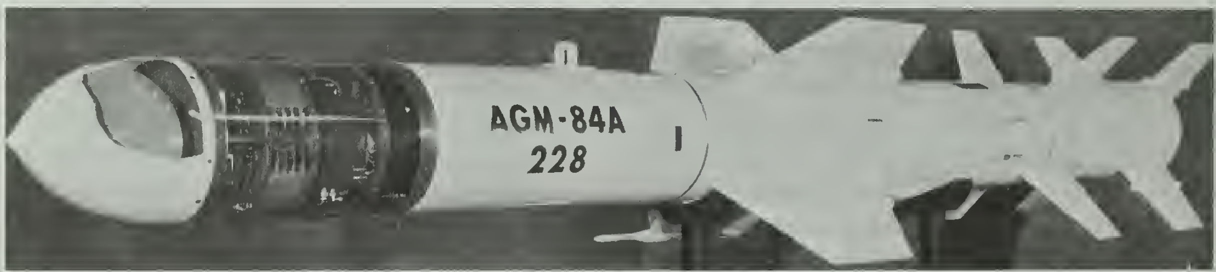
The program, with incurred costs about 4 percent less than the contractor's baseline budget, utilizes incentive contracts, effective management tools, a predetermined work breakdown structure, and independent cost estimates to assure accomplishment of development objectives.

On this project, contractors responding to a Request for Quotations were required to submit quotations in accordance with a given work breakdown structure on a line item basis. This permitted a direct comparison of each offeror's quotation with each other at the fourth level of the work breakdown structure, and with an independent estimate. The contracts were awarded on the basis of cost and technical considerations defined within work breakdown structure elements.

Monthly cost and technical performance reports were required from the contractors and laboratories. These reports are a disclosure by elements in the work breakdown structure of technical progress and of the dollars and hours expended by labor category. They provide an analysis of variance from the budgeted and scheduled work rates and hours. This gives in-depth visibility and allows one to trace the program's progress. The program baseline is updated as a result of continuous Government review of contractor and laboratory performance. The continuing baseline update and trend analysis, besides being cost effective, are valuable tools to use in negotiating changes, monitoring technical/cost/schedule performance, and identifying problem areas.

Proving the technology, being hardware-oriented, requiring milestones to be met before the next phase begins or funds committed, and constant detailed monitoring of the contractor's progress all combine to make Harpoon a sound program. Both Government personnel and the contractors involved recognize the importance of teamwork and the principle of program management. Specialists in design, technology, cost analysis, logistic support, contracting and management work cooperatively to promote cost effectiveness.

These examples demonstrate what we can, and sometimes do, accomplish. The question is, how can we secure such results more often? Budget constraints require that the innovative momentum demonstrated so far must be accelerated with conscientious effort by all concerned to produce reliable and cost effective defense systems. The economy and security of the Nation demand it. □




Model of the Harpoon, an air/ship launched anti-ship missile.

# Navy Engaged in Concentrated Effort To Standardize Tactical Digital Systems

There are many reasons for the establishment of a standard item of military equipment. Typical advantages are in the areas of reducing the varieties of spare parts to be stocked, with resultant reductions in inventory and procurement costs; reducing the time required to train systems operators and, correspondingly, reducing training costs and equipment maintenance facilities in terms of equipment and personnel.

These standardization advantages are true of almost any item of military equipment, but are of particular significance to the Navy for reasons peculiar to it alone. Ships are extremely expensive items to build and traditionally, regardless of the original design function, they have become multi-purpose in the nature of missions assigned. This multi-purpose nature coupled with high replacement costs has resulted in long platform life. Since it can be expected that any new ship entering the Fleet will be in service for at least 25 years, life cycle maintenance costs become very important items. Standardized system components are a major factor in keeping down life cycle costs.

Another Navy peculiar situation is the long time between the installation of a system on a ship and the replacement or upgrading of that installation. This system installation cycle may easily be four to five years, which again highlights the gains in reduced inventory and maintenance costs that can be achieved through standardization.

Finally, ships by their very nature will be operating at sea for long periods of time without having the daily ability to "touch base" with their maintenance installation. This means that standardized system components within one ship and within ships of the force will enhance the ability of the force to maintain the parts inventory necessary to sustain the systems embarked.

**Rear Adm. J. E. Rice, USN**
***Director, Tactical Digital Systems Office***
***Naval Material Command***

## Standardization Tools

Continuing efforts of both the Chief of Naval Operations and the Chief of Naval Material have been directed, as a Navy policy since

1966, to reducing multiplicity and proliferation; procuring proven, reliable and supportable equipment, and controlling the changes that can be made to that equipment.

Among the tools employed to reach this standardization goal are configuration control boards, user design groups and industry advisory councils. One area in which the Navy's standardization effort has been concentrated is that of tactical digital systems.

The requirement for developing and acquiring tactical systems that utilize digital processors is generated by an increasingly sophisticated threat via air, surface and sub-surface. To meet this threat within the requisite time and accuracy limits, the Navy has developed high speed, high accuracy systems that require militarized, digital processors programmed in high level language.

Recognizing the need to reduce the number of different processors that could be developed for use with the different tactical systems, the Navy adopted in November 1971 the AN/UYK–7(V) as its standard digital processor. At the same time, CMS–2 was adopted as the standard high level programming language. The Marine Corps, because of its inherent close relationship with the Navy, monitored the Navy actions and has specified the same processor and language for use with its developing systems.

## Mini-Processor Development

The AN/UYK–7(V) processor is an efficient and powerful machine, but has a greater capability than was required by a number of the smaller tactical systems being developed. It is also larger than is required for many of these systems. Because of the size, power and cost of the AN/UYK–7(V), system developers began to incorporate mini-processors into their new system designs. The problem of proliferation, solved in the case of larger systems by the adoption of the AN/UYK–7(V) as a standard, raised its head once again.

To avoid multiplicity and proliferation, the Navy, and specifically the Tactical Digital Systems Office (TADSO) under the Chief of Naval Material, formed a design review group composed of various users and prospective users of tactical digital mini-processors. This group, with Marine Corps participation included from the outset, examined the various applications that could be expected for a tactical digital processor. With technical assistance from the systems commands and the Naval Ship Engineering Center, the group developed a specification for a standard tactical mini-processor commonly called the Mini-UYK.

The group had as its specification objectives the identification of a combat system processor for the smallest tactical subsystem and retention of a building block capability. The mini-processor was required to cover the lower range of capabilities not possessed by the existing AN/UYK–7(V) and be compatible with the AN/UYK–7(V). The mini-processor was required, to the greatest extent possible, to utilize standard or existent parts or modules and had to be capable of being programmed on other Navy processors with a minimum of change. Finally, the mini-processor's scheduled availability had to be such that all users could be accommodated.

## Specification Characteristics

The specification for the Mini-UYK required the following characteristics:

- Small size—a maximum of 5 cu. ft. and 200 lbs.
- Militarized—built to Mil–E–16400.
- Highly reliable—employ proven, standard components already in existence or a part of current technology.
- Optimized maintainability—repair and maintenance criteria developed to minimize training requirements. Reduce MTTR through software diagnostics.
- 16 bit word length.
- Memory—8,192 words minimum, expandable up to 65,536 words.
- Speed and timing—equal to or better than AN/UYK–7(V).
- Based on *existing* mini-processor design to minimize the time and effort required for production.

On April 27, following the evaluation of bids, a contractor was selected to produce the Mini-UYK processor, designated AN/UYK–20(V), according to the required specification which was met or exceeded.

## Software Compatibility

In the software area, the life cycle cost of

tactical systems program development and maintenance may easily run three to four times the cost of the system hardware. Standardization of both the processor and the programming language can reduce the number of programs to be developed and significantly reduce the program maintenance costs when proper configuration control is maintained on the processor. A standard processor means that there is no need to develop a unique compiler—to convert from the programmer's program language to the processor's machine language—for each type of nonstandard digital processor procured. Programs developed to run for one system are more easily transferable to other digital systems if the digital processor and the programming language are compatible. Increasing transferability is an excellent means of bringing about a reduction in program development costs.

A final, albeit not cost reducing, benefit of processor standardization is that system redundancy can be provided to critical combat systems through the assignment of machines from one tactical digital system to another, should one processor be forced to go off the line for a period of time. The redundancy benefit is of particular importance when one thinks of the Navy peculiar situation, mentioned earlier, of ships operating for extended periods of time at sea and far from their maintenance base ashore.

## Standardization Pitfalls

Fairness demands that one look again at standardization to determine if, in fact, there may be pitfalls which outweigh the previously discussed advantages. One obvious drawback that must be faced from the start is that once a system component or language is locked in the advantages that can be gained by keeping up with the state of the art are lost. Pursued far enough, it can be argued that standardization will stifle the development of new equipment and new systems. In the case of digital systems, the efforts of the computer industry in the past tend to effectively counter this argument, since it has been possible to develop standardized generations of equipment which stabilize the advancements over reasonable time frames without invoking minor advances on a piecemeal basis.

Another common argument against the development of a standard is that, in achieving a standard, it may be necessary to compromise to such an extent that the developed item may not be operationally effective. This can be overcome by disallowing any proposed standard that would significantly impair performance requirements.

Finally, standardizing on one programming language may result in inefficient use of the speed and memory capabilities of the processor. However, here again optimization of the processor will tend to relegate the inefficiencies to areas where they are offset by gains in the overall operating characteristics of the computers. In programming language, as with items of hardware, selection of a standard and sticking to it precludes the maximum use of state-of-the-art techniques.

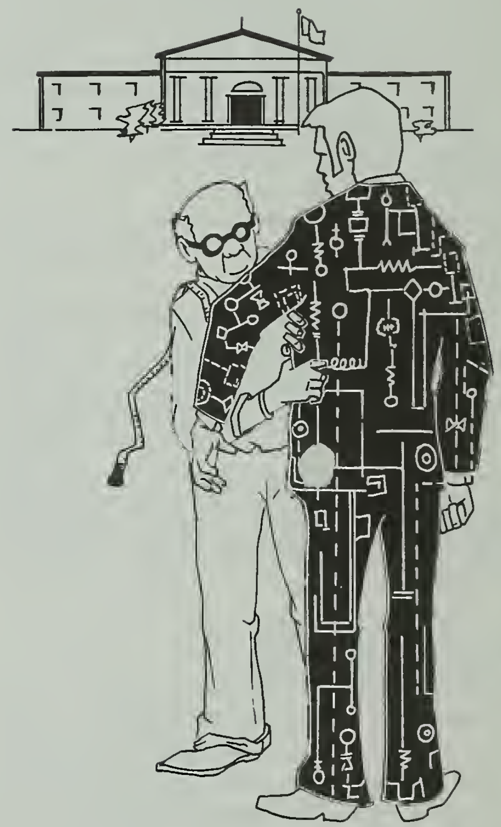
## TADSO Responsibilities

In the Navy, the arguments regarding the pros and cons of standardization have been routine among system developers for years but the arguments have been resolved in favor of standardizing. The central Navy Departmental Standardization Office of the Naval Material Command, established in 1955, was reinforced in the fall of 1971 by the establishment of the Tactical Digital Systems Office (TADSO) to direct and coordinate Naval Material Command efforts in the areas of standardization, acceptance standards and configuration management of both hardware and software for the digital combat systems world.

Requirements that are currently identified for the mini-combat system processor include systems under development for the Naval Air, Electronics, Ordnance, and Ships Systems Commands as well as for the Marine Corps. It is expected that additional requirements will be identified as the knowledge of the standard mini-combat system processor becomes more widespread.

The gains sought in this standardization effort are the classic ones of reduction in procurement costs, inventory and maintenance costs. In addition, it is hoped the establishment of this standard will result in the elimination of the development costs of unnecessary sizes, types and varieties of similar but specialized processors. □

# Tailoring the Engineering Curriculum



Standards and specifications are today of increasing interest and importance in Government, commerce and industry. They give rise to many utterances of individual wisdom and interpretation by political heads of state, industrial executives and chief engineers. The question is often asked, "What are the engineering schools and colleges doing about including courses on standards and specifications in the engineering curriculum?"

The answer to this question is, "They are not really doing very much about it." But this answer does not imply the concepts of standards and specifications are completely ignored in the teachings of most of our schools and colleges of engineering. There are some educational and curricular problems associated with engineering standards and specifications. There are certain ways Government and industry may assist and encourage our schools and colleges in identifying appropriate content material and in more effectively teaching these meaningful and necessary concepts to a wider class of students in the future.

The Random House Dictionary of the English Language defines the words "standard" and "specification" as follows:

*Standard:* 1. An object considered by an authority or by general consent as a basis of comparison; an approved model. 2. Any-

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Opinions expressed herein are those of the author and not necessarily those of the Department of Defense.

thing, as a rule or principle, that is used as a basis for judgment. . . .
*Specification:* 1. The act of specifying. 2. A detailed description of requirements, dimensions, materials, etc., as of a proposed building, machine, bridge, etc. . . .

It must be noted the concepts of "object" and "dimension" are the primary elements in the referenced dictionary definitions. It is then natural that the general public and many officials would think dominantly in terms of these somewhat restricted definitions in matters relating to official standards and specifications. It is a fact, however, that technical and operational interpretations and applications of these concepts have evolved significantly in industrial uses.

In early industrial uses of standards and specifications, and even today, a typical manufacturer would rather produce items of a product to specified physical or dimensional characteristics than to specified performance or other characteristics. When a dimensional requirement on a drawing or blueprint had been met at any stage of manufacture, it would also meet that same requirement in the finished product. This is not true, however, for performance requirements. It is well known today that a product item may meet all the requirements of the blueprint and, yet, fail in its performance characteristics.

## A New Breed

In the last 50 years standards and specifications have become very long, complicated and formidable documents. They usually contain extensive sets of drawings and elaborately written book-like compilations. They often embellish infinite details (boiler plate) considered legally necessary but rarely read. They are further complicated by the differing styles of issuing agencies, prime contractors, etc. Many issuing organizations follow practices of calling out still other more general and specialized standards and specifications as being applicable, when only a few paragraphs contained in them are truly applicable.

In more recent years, therefore, a new breed of standards and specifications has emerged. It is not always easy to draw a significant distinction between standards and specifications. Sometimes the words are used interchangeably, even though they have fundamentally different meanings. At the present stage of industrial development, specifications continue to state for the referenced item all requirements, relevant test methods, and acceptance criteria. A standard can be expressed as a numerical value or a discernible state of the referenced item against which to measure or compare an observed quantity, quality, procedure, practice, or program.

## Current Application

Government and industry currently make extensive use of official standards and specifications in contractual documents for the design, development and fabrication of facility complexes and construction processes, hardware devices and equipment configurations, software programs and data functions, public utility and service operations, safety and performance assurance procedures and management information and control systems. We may expect the emergence of still other new parameters and systems of applicability for standards and specifications with the increasing societal attention to health, recreation, environment, safety, product liability and quality of working life.

It is then not surprising that national thinkers, planners and leaders do and will continue to urge that greater attention be given to standards and specifications in the Nation's educational system and in industry's executive development and training programs. It is also natural that these leaders would think first of our schools and colleges of engineering to undertake this important responsibility.

## Public Systems of Higher Education

To arrive at a relevant and rational set of recommendations for curricula considerations for governmental and industrial types of standards and specifications, one should understand the typical structure and educational objectives of the public higher educational institutions in the Nation. The tendency is increasing for the individual states to divide their public higher educational institutions into a tripartite system:

• *Universities.* The universities are usually assigned the primary responsibility for basic research and related graduate teaching in the

sciences, the arts and the professions, including engineering. The universities also have responsibility for instruction and curricular leadership for basic and new approaches to undergraduate education for students planning to create new systems, new arts, and new technology as a life's work. Only students with the highest qualifications and potential are admitted at the freshman, junior or graduate levels. In addition, the universities may prepare or sponsor special seminars, symposia and conferences involving applications of newly developed knowledge and procedures for presentation through the extended university to governmental, industrial, engineering and other specialized communities who can utilize the information presented. Engineering graduates of the universities are considered to be better prepared to work creatively on the frontiers of knowledge and to design new product or service systems for the future benefit of mankind.

• *State Colleges.* The primary function of the state colleges or state universities is the provision of instruction for college students, usually through the master's degree in the liberal arts and sciences, in applied fields and in the professions and vocations including engineering. Faculty research is authorized to the extent that it is consistent with the primary function of the state colleges and state universities and with the facilities provided for that function. Students with middle to higher academic and career qualifications attend these institutions and they are admitted at the freshman, junior or graduate levels. In addition, special short courses, programs and conferences involving current policies, practices and procedures are planned or sponsored for presentation to industrial, practicing and professional people. Engineering graduates of the state colleges are primarily prepared and trained to utilize the current state of knowledge and art in engineering to operate and to improve the beneficial effects of engineering design, development and technology to society.

• *Community Colleges.* Public community colleges in the states and municipalities usually offer instruction through, but not beyond, the 14th grade level. This instruction may include, but shall not be limited to, programs in one or more of the following categories: standard collegiate courses for transfer to higher educational institutions; vocational, technical and trade fields tending to employment; and general or liberal arts courses. High school graduates with any level of qualification may not be denied admission to courses or programs of interest in these institutions. Studies in these fields or categories can lead to the associate in arts or associate in science degree. Vocational graduates of these institutions are prepared to find useful employment in a wide spectrum of laboratories, production and fabrication processes, individual trades, services, etc.

## New Schools and Colleges of Technology

Certain types of new schools and colleges of technology are emerging on the educational institution scene. These new schools or colleges typically have separate divisions for technologies related to engineering, industry, manufacturing, construction, management, etc. At least one of the Nation's newest state universities, with a school of technology in the planning stage, shows a technology division for the presently popular environmental and urban studies. These technology oriented schools or colleges are to be found in a number of universities, large and small, and state colleges. Some report to the college of engineering and others are within the colleges of liberal arts or education. They admit a very broad class of students with varying degrees of preparation. They plan four year educational programs for individual students so almost any college work taken previously will count toward a bachelor of technology degree. Students are admitted to the technology programs at almost any time convenient to the student.

It is significant the curricular programs of some of these schools and colleges of technology are being reviewed and given certain types of approved or accredited status by the American Society of Engineering Education and by other engineering professional development organizations. It is also possible in some states for technology graduates to apply for and to earn recognition as registered professional engineers through examination and professional activity. It is customary for four year technology graduates to be employed in a very broad spectrum of engineering, production and service func-

tions of society, and to progress up the experience ladder to middle and high level positions.

### The Engineering Profession

In Government, industry and education there is a tradition of wide ranging usage of the words "engineer" and "engineering." The engineering profession has similarities to the professions of medicine and law, but it also has significant differences. Medicine and law are sometimes referred to as *exclusive professions* because one must pass state board examinations and be licensed before he can begin to practice medicine or law. Engineering may be thought of as an *inclusive profession* because of a much more open door invitation to join and practice it.

It is difficult to plan specific engineering educational programs and to know whether or not a given subject should belong to that curriculum. An instructional program of study of standards and specifications is just such a subject and curricular problem for engineering. There exists today an almost exponentially increasing need in Government and industry for improved old and for new types of standards and specifications. Perhaps the greatest contributing force to this need in the last decade has been the Government's policy or practice of selecting a single or a consortium prime contractor for large scale systems developments and the resultant requirement that a very large fraction of the work be done by hundreds of smaller subcontractors.

Moreover, it is predicted that some of the Nation's largest utilities and/or service organizations, which have throughout their existence designed and manufactured their own specialized equipment, will turn more and more to competitive outside bids on certain products. To do this successfully, they must first develop different and better types of standards and specifications. The amount of this work is difficult to estimate, but it is obviously a large task.

### Summary and Conclusions

A perusal, even though limited, of the history of and the rapidly evolving literature on standards and specifications makes abundantly clear the following observations:

- Uses of standards and specifications by Government and industry have increased enormously in the past. This will continue in the future not only for traditional products and services but also for nearly all human activity where negotiation and agreement is used.

- Clearly defined standards and well written specifications are the best known or conceivable instruments for successful negotiation and agreement between all types of producers and users or servers and the served.

- Appropriate standards and specifications are applicable to any input, thruput, or output of any intended unit, component, module, or segment of a product or service system.

- A real need exists for greater national and international uniformity in the structure, composition and understanding of standards and specifications for products and services.

- More attention, space and time should be devoted to standards and specifications in appropriate curricular programs of all of our educational institutions. Schools of engineering and/or of technology with greatest potential for effective contribution and intrinsic interest in this type of education are to be found among the state colleges of the tripartite systems of public higher education in the states. The universities and community colleges can contribute significantly in their respective spheres of educational responsibility.

- It is of critical importance that the United States undertake a strong international leadership role in standards and specifications matters. In this, Government and industry should collaborate most effectively.

These observations are made in full recognition that the entire world is neither all friend or all foe.

### Recommendations

The viewpoint of this article has been that of the educational or curricular aspects of standards and specifications. Consideration of educational or curricular aspects does not, however, minimize the roles and tasks of Government and industry in meeting the total needs of the Nation relative to the future utilization of standards and specifications. The voices of Government and industry are heard in our

educational institutions, and our schools and colleges of engineering and of technology are increasingly influenced by them.

The following statements are first related to standards and specifications in general, but they are progressively restricted to the associated educational and curricular problems in particular. It is recommended that:

• The U.S. Government form an ad hoc group of highly qualified people to study problems related to current and future uses of standards and specifications in all major areas of concern to Government, industry, society and education. This group should be composed of three to five appropriate representatives from these areas, and it might seek reciprocal international representation. The group should be charged, budgeted and given access to appropriate support personnel, facilities and information. The study should be expected to extend for two years with follow-up service, delegation and implementation.

• The findings of this group should be published and recommendations should be made for all areas of use for standards and specifications.

• With respect to the educational and curricular aspects of standards and specifications and because of the two foregoing recommendations, the Federal Government and industry should formulate and issue high class, well designed instructional information about the basic structure, content and applications of standards and specifications in all areas of human activity. This material would consist of books, documents, slides, charts, transparencies, movies, etc. A particular agency or group of the Government should be given cognizance and responsibility for the currency and updating of this information. This information should be made available to approved schools and colleges that are giving courses or other instruction in standards and specifications.

• Congressional and industrial long-term funding should be be sought for partial support of this type of educational activity throughout the United States. The level of financial support for a particular institution would be commensurate with its needs and approved educational programs in standards and specifications. The funds might also include support for professorships or chairs for a limited number of distinguished faculty who, in addition to regular engineering and technology teaching, would give special lectures and presentations in Government, industry and other educational institutions.

• Funding through the National Science Foundation or the National Academy of Engineering should be provided for periodic study and writing groups to produce new and updated materials for classroom instruction on standards and specifications.

• Certain laboratories should be funded and established for experimentation with problems of developing and meeting certain types and levels of standards and specifications with current or planned new industrial equipment and processes.

• Other educational, industrial and governmental activity should be planned to support the Nation in its approach to optimum uses of standards and specifications at acceptable levels of cost, quality, performance and human appreciation.

Nothing in these recommendations is intended to suggest restriction of the functions of existing professional organizations in Government and industry which are concerned with standards and specifications. The opportunity would be all the more to work through and with them.

This article is a brief attempt to present certain educational aspects of a vast problem and opportunity facing the Nation. The recommendations offered may appear to pass the buck of cost to other than the local tax bases of the respective educational institutions. This is not the case. With the recommended financial and leadership support of Government and industry assured, then local funds through taxes and tuition can be expected. Worker interest, pride and maturity will follow. □

# Culprit of Contract Appeals Is Ambiguous Specifications

When military specifications become a part of a contract instrument they bring into the procurement process a vested industry interest. A specification is a technical document subject only to Government interpretation when used solely within a Government activity. When it becomes part of a contract, it becomes subject to interpretation not alone by the Government but by the contractor as well, with possible serious cost implications not originally envisioned. Since interpretation of specifications has been determined by numerous opinions of the courts to present issues of law, specifications preparation must conform to those principles of interpretation established by opinions of the courts. Additionally, to meet targets of the contractual cost to produce, particular attention must be given to the language of specifications work statements and technical data to avoid cost surprises.

In a report by the Joint Logistic Review Board concerning procurement and production,[1] an observation was made in reference to specifications as a contract instrument and the cost and delinquency effect of faulty contract specifications. The report states the Armed Services Board of Contract Appeals (ASBCA) considers approximately 900 cases a year and estimates

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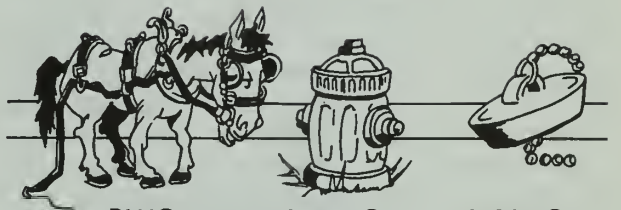
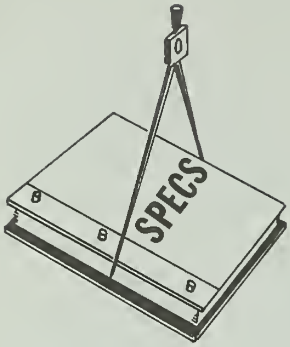



that 50 percent of these are caused by improper specifications. The number of cases involving specifications being appealed to the ASBCA has been increasing since 1965.

Specifications containing ambiguities and language capable of diverse interpretations introduce into the contractual document possible contract disputes with attendant increase in costs. Quality assurance and technical data personnel are responsible for ensuring that specifications are accurate. While staff activities have the responsibility of verifying the Government can accomplish its requirements at the time the purchase request is being prepared, the Joint Logistics Review Board found that the "Government is frequently faced with a contractor's complaint of ambiguous or erroneous specifications causing distracting and time consuming delays and arguments finally ending before the Armed Services Board of Contract Appeals." Reference to ASBCA cases handled in 1972, for example, discloses a great pre-

[1] *Memorandum, Office of Secretary of Defense, Subject: Joint Logistics Review Board, Feb. 17, 1969, Monograph 16, Procurement and Production, p. 64.*




ponderance of cases which involve contract specification problems.

## Clarification Opportunities

In the procurement process there are two principal opportunities to correct errors and ambiguities in specifications.

An opportunity for clarifying specifications as a contract instrument exists in the pre-award survey through the Program for Improvement of Procurement Data Packages and Specifications and the preparation by the quality assurance representative of the Procurement Data Package Recommendation/ Deficiency Report and Specification Analysis Sheet. In the course of review of the incoming contract, the quality assurance representative coordinates, through the administrative contracting officer, with the procurement contracting officer any correction, clarification, or needed interpretation of the specification as a contract instrument.

Another opportunity for clarification is at the post-award conference held with the contractor to ensure he is familiar with all the terms and specifications of the contract. The obligations of the Government should be thoroughly reviewed at this time and an immediate correction of any discrepancies should be provided to minimize any adverse effect on contract performance. The key man on the contract administration team is the administrative contracting officer. He has the overall responsibility in managing the assigned contract to ensure the contractor's total performance is in accordance with the contractual commitments and that the obligations of the Government are fulfilled. However, he relies heavily on other members of the contract administration team which include production, quality assurance and industrial property personnel.

## Accuracy Is Essential

Clear and accurate specifications are essential to effective procurement. Conflicting or ambiguous requirements are likely to be interpreted against the Government since it supplied the specification. The order of priority and the limitations of different documents should be clearly stated to establish, in the event of conflict, whether or not specifications have priority over drawings, the relation of general specifications to detailed specifications, and the applicability of other contract documents that describe the supplies. The Order of Precedence clause in the Armed Services Procurement Regulation (ASPR) may be used to provide a contractual description of the desired priority. The bid or proposal solicitation should also make clear what particular issue of a specification governs since specifications having the same general title are revised from time to time.

While specifications should be clear and complete, they should not contain conditions that unreasonably restrict competition. To illustrate, a specification once used for the procurement of a commercial grade of refrigerator required a magnetic door latch. This type of latch was a standard feature on only one of the dozen or so commercially available products. As a result, it kept all but one manufacturer from bidding on the procurement. The other firms were not interested in undertaking the engineering and retooling necessary to incorporate the change in their products. Requirements like this not only restrict competition, they can also lead to costly delays in awarding a definitive contract. This can happen, for example, if a contractor whose product is restricted by unnecessary requirements protests to higher authority.

## Varied Specification Types

Procurements are initiated and contracts are placed at several points in the life-span of a complex item. As an item moves from research and development into production, it can be defined and described more precisely. Research investigations, for example, are commonly procured on the basis of flexible work descriptions

which are often broad and general. These give the contractor a great deal of freedom. During the early developmental stages of an item, work descriptions and specifications are comparatively general. By the time the production stage is reached, however, it is expected that firm plans and specifications will be available. Often these are prepared by the development contractor and approved by the Government. They are then released so production quantities may be procured competitively.

It is at the approach to the production phase in the procurement cycle that the opportunity exists for further technical and legal review of the specifications, drawings and other parts of the technical data package as they are being incorporated into a contract instrument.

The specification as a contract instrument should assure the Government's ability to inspect for compliance. This would enable technicians to see problems as they arise, determine desirability of changing to a detailed specification or changing to a performance specification, and determine that requirements are too restrictive or not sufficiently restrictive and many other specification revisions.

It is necessary to test not only a contractor's ability to manufacture a given item, but the adequacy of the specification in mass production in accordance with its requirements.

## Defective Specifications Invite Claims

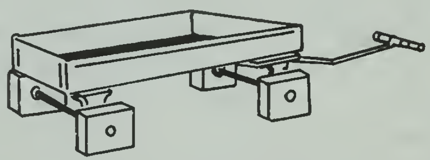
There is presently a deep concern over rising costs of defense procurement, the contingencies and mounting costs of unexpected contractual claims of every variety.

This concern was expressed by Dr. John S. Foster Jr., Director of Defense Research and Engineering, at a meeting of the American Ordnance Association at which he indicated that "one of the priority actions is to gain control over the escalating costs of weapons systems, costs that have been tripling. . . . As this has happened, we have been forced to procure fewer and fewer copies."

We have evolved from the term cost overruns to cost growth and, in turn, to the concept of cost threshold breach. We have devised concepts for cost control, such as should cost, design to cost and cost to produce. Public Law 87–653 assures recovery of costs where proposals are based on inaccurate, noncurrent and incomplete cost data. We have also begun to control costs through the greater visibility provided by the Cost Accounting Standards Program under Public Law 91–379, concurrently with the control of costs under Section XV, "Cost Principles," of the Armed Services Procurement Regulation.

While the DOD contract has numerous clauses unrelated to specifications which are involved in litigation through boards, state and Federal courts and the U.S. Supreme Court, one of the most complex sources of contract litigation involving complex technical issues and unexpected cost is found in the specifications, work statements, drawings and other technical data, comprising an integral part of the contract instrument. This is an area which invites highly trained lawyers, accountants and engineers to present claims to the Government.

Defective specifications as a contractual document will produce all manner of claims under the doctrines of Constructive Changes and Impossibility of Performance.



## Legal Considerations

The need for sound technical and legal draftsmanship of specifications as contractual instruments with an awareness of the current state of the art and which essentially possesses exclusive or peculiar knowledge of the field, whether Government or contractor, arises out of a consideration of the principles very aptly summarized by the Trial Commissioner in the recent case of J. A. Maurer v. United States in which the U.S. Court of Claims said:

> "The issue of technological impossibility of performance has arisen frequently in Government contract litigation, at times in this and other Federal courts, and more often in the Armed Services Board of Contract Appeals. . . . It typically occurs in fixed price research contracts and in supply contracts containing performance type specifications as opposed to design type.

It also occurs in straight supply contracts where the precise technology has not been settled and the parties either underestimate the anticipated problems or encounter them contrary to expectation. For the purpose of the case under consideration the inquiry is restricted to the type of impossibility involving a scientific or technological obstacle as a ground for excusability under the unassigned 'no fault or negligence' language of the standard Default clause, rather than the more common type of performance excuses expressly enumerated in the clause as acts of God or Government, war, weather, illegality, etc."

Judicial and administrative attitudes in the rulings on the issue display wide diversity, ranging from an uncomprising assumption-of-risk sternness to more reasoned approaches, even though the claims in those instances were dismissed. There is instinctive sympathy for the blameless and diligent contractor who, while accepting the risks of performing a fixed price contract which pushes the frontier of a particular scientific or manufacturing technique, encounters unanticipated technical problems preventing performance. Despite this, the decisions reflect a very legalistic prevailing view that a contractor is bound by his contract, but there are exceptions.

The assumption of risk defense is less strictly applied where the specifications are drawn by the Government than where they are provided by the contractor. The converse is also true. This rests principally on the theory that the author of specifications impliedly warrants they will work. The warranty theory has greater validity with respect to design specifications than to performance specifications. Knowledge of opportunity for knowledge of the risks prior to contracting is held against the contractor, just as superior but unimparted knowledge on the part of the contracting agency is held against the Government. But the superior knowledge of another Government agency is not to be imputed to the contracting agency.

## Impact on Defense Economics

The specification problem is one of considerable magnitude not only in terms of its intrinsic technical and philosophical complexity, but also in terms of the impact of this problem on the economics of defense. If we consider specifications in a general sense, *i.e.*, documentation that defines requirements for procurement, we are concerned with "paper" that favorably or unfavorably affects over $20 billion of procurement annually. These specifications are supported by a vast quantity of related documents. Each year, for example, DOD acquires approximately six million new or revised drawings. It distributes over one billion prints annually. The Specification Index lists over 35,000 specifications.

The foregoing suggests some of the historical causes of the specification problem. The historical facts might be considered the remote causes of the problem. There are, however, more immediate causes, the most important of which has been the failure over a long period of time of the executive levels in both Government and industry to give adequate management attention to this area. This situation exists for many reasons, not the least of which is that management frequently considers specifications as details to be resolved by technicians. There is a tendency to overlook the fact that specifications and the manner in which they are prepared represent major economic decisions. Additionally, DOD has lacked a strong centralized authority to formulate and enforce comprehensive specification policy. This is not to denigrate the long history of military efforts to develop joint Army-Navy specifications, including the work of the Munitions Board and later the Defense Supply Management Agency, the Armed Forces Supply Support Center and, finally, the Defense Supply Agency. Nonetheless, strong central authority over specifications has been lacking.

The manner in which the specification problem is resolved has an immediate impact on cost of procurement, competition, provisioning, and weapons reliability. Unless the specification problem is solved in a rational and comprehensive way, it is inevitable that the vast array of nonstandard documents will continue to come into existence in the form of expedited purchase descriptions or in other forms that do not contribute to permanent improvement in procurement management and make it almost impossible to control specification proliferation. It is of salient importance that specifications


be prepared in accordance with explicit concepts and rules to assure fairness in competition and to protect the integrity of materiel acquired by DOD. I am of the opinion that "buy in" practices are encouraged by opportunities for specification interpretation giving a contractor an opportunity to assert substantial claims to avoid a loss contract due to a buy in.

## Summary

Specifications as a contractual instrument serve the dual purpose of assuring that the product or service contracted for is correctly defined and that the Government will be assured through contractor responsibility that the product tendered by the contractor is of the defined quality and reliability.

I view the specification as a contractual document from the reference point of field experience including participation in litigated cases as a contracting officer. Each of us views matters from different reference points and the views are different. The specifications as a contractual document can be improved by establishing a centralized control of all significant specification interpretations involving substantial costs. This would include a central data bank of interpretations which could be readily retrieved. The interpretations would be controlled and reviewed by a technical legal group with expertise in the field of specification draftsmanship and interpretations. Special boards of appeal, technically as well as legally oriented, could be established to consider and promptly resolve specification appeals. This activity could later be decentralized as decentralized expertise in this field develops. The central control group through study of board and court cases could establish cannons of interpretations and construction of specifications and, after coordination with industry, seek appropriate codification. □

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**Mechanical means of communication have their important places; but they are only adjuncts. None of them can take the place of personal man-to-man contact.**

—William G. Werner

# The Program Manager and the Subcontractor: Hands On or Hands Off?

On almost every defense system acquisition program, subcontracts account for more than half of the prime contractor's costs. One prime contractor, for example, subcontracts 66 percent of a missile program while two others have subcontracted 60 to 70 percent of aircraft and destroyer programs, respectively.

A general idea of the value of subcontracts can be gained from a recent report of the General Accounting Office (GAO).[1] The Comptroller General estimates that 116 Army, Navy and Air Force programs will cost more than $153 billion. Even after deducting prime contractors' fees or profits and general administrative expenses, it is apparent that a major part of this outlay will go to subcontractors. And therein lies a key questions for the DOD program manager: How can he control these costs when he has no direct access to subcontractors?

The DOD program manager's contract, being with the prime contractor, precludes a direct legal relationship with subcontractors. He has no privity of contract with them and must avoid putting himself in a position where he, in effect, relieves the prime contractor of responsibility and liability for subcontractors' performance. This is well understood by DOD program managers who have a good appreciation for chain of command.

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"Hands off" seems to have become the guiding doctrine in the program manager's relationship with subcontractors. But with the great emphasis on costs in acquisition, how can the program manager afford *not* to get more involved in subcontractor control? In short, where in practice is the dividing line between hands on and hands off?

## Guidance and Doctrine

Official and unofficial guidance is remarkably sparse on subcontracts, particularly regarding the management aspects as distinguished from the legal relationship.

Section XXV of the Armed Services Procurement Regulation (ASPR) treats subcontracts

[1] *"Cost Growth in Major Weapon Systems," Report by the Comptroller General to the Committee on Armed Services, House of Representatives, March 26, 1973, p. 1.*

briefly. One section of the regulation deals with evaluating and reviewing prime contractors' procurement systems. Another section concerns the Government's right to approve subcontracts proposed by the prime contractor.

Tucked away in the next to last paragraph of Military Standard 881 on Work Breakdown Structure (WBS) is another statement regarding subcontracts: "The prime contractor shall be responsible for traceable summarizations of subcontractor data supporting his prime contract WBS elements. The prime contractor may negotiate any WBS with a subcontractor that permits the prime contractor to fulfill his contract WBS requirements and which provides adequate control of the subcontractor."

Beyond these two directives are incidental references to subcontracts in documents such as DOD Instruction 7000.2, "Performance Measurement for Selected Acquisitions," and the Handbook on Cost Information Reports. The role of the DOD program manager in subcontractor management, however, has received scant attention.

## Reasons for Subcontracting

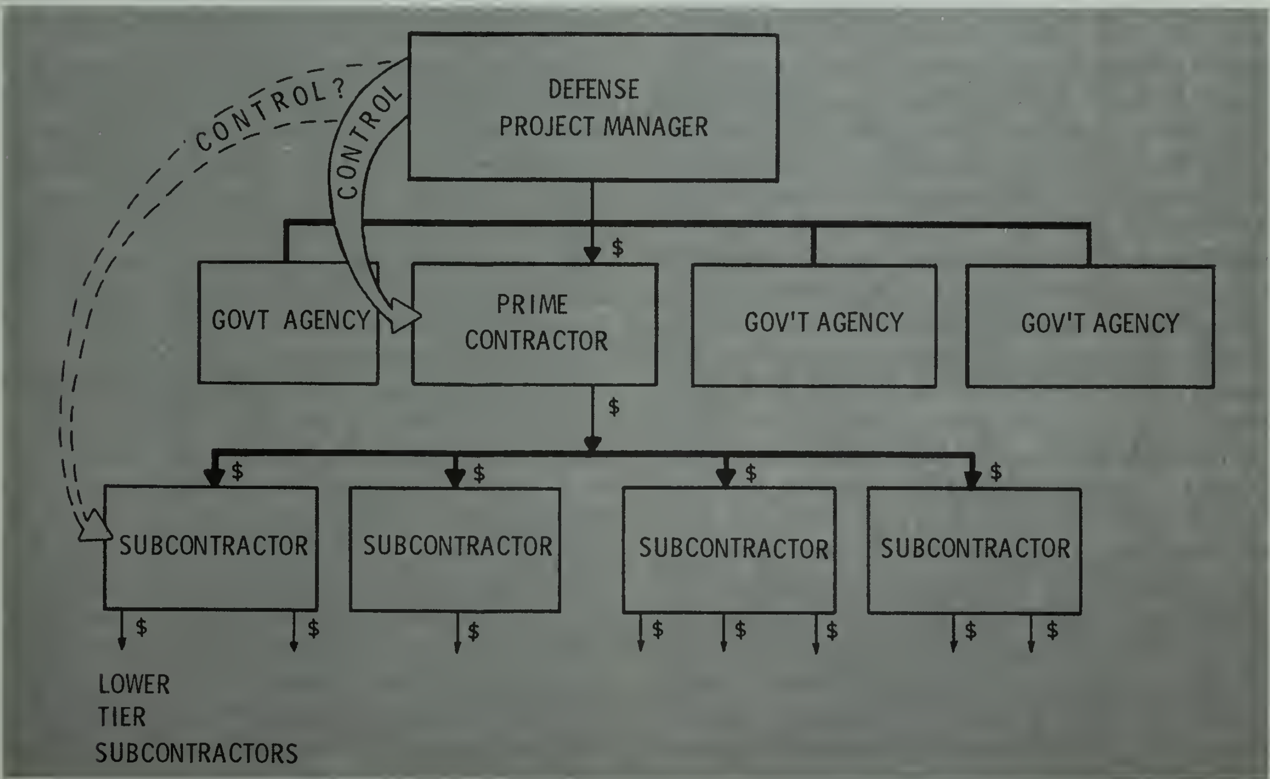
It is apparent that whatever action the DOD program manager takes with regard to subcontractors must be exercised through his prime contractor. This article will consider some of the measures he can take to ensure adequate control.

At the outset, a natural question arises: Why do prime contractors subcontract so much of their work?

First, there are fewer defense systems being procured although systems' dollar magnitude has increased. This means there are fewer prime contractors. As a result many former prime contractors are increasingly assuming a subcontractor role, as well as occasionally being a prime contractor.

Another reason for subcontracting is that as systems have grown in complexity, prime contractors have necessarily subcontracted for subsystems outside their in-house expertise. Propulsion, guidance and control and electronic subsystems, for example, are typically subcontracted by airframe contractors.

Subcontracting gives a prime contractor flexibility in coping with the accordion-like requirements of defense procurement while maintaining a relatively stable in-house base of skills and facilities. It dampens the effect of a com-



pany's expanding and contracting to accommodate changing DOD requirements.

Whatever the reason for subcontracting, subcontracts are often so large that they are, in fact, subprograms projectized and managed in a manner similar to that of the prime contractors and the Military Services. Subcontractors two and three tiers below the prime may also have a program manager, program organization, and plans, controls and objectives corresponding to those of the DOD program manager and his counterpart in industry, the prime contractor program manager. The techniques and principles of program management apply at these lower levels, just as they do at the level of the DOD program manager.

### Who Manages the Subcontractors?

Let's look now at some actions the DOD program manager can take to ensure that his program's subcontracted dollar is well spent, without his becoming directly involved with the subcontractor.

Sometimes the fault for loss of subcontractors' control of costs is traceable to the prime contractor and, more specifically, to the matter of who in the prime's organization has responsibility for what. On a large aerospace program a few years ago a company's program engineer for propulsion assumed that he had full responsibility for both in-house and subcontract propulsion work because a documented company policy assigned this responsibility to the program engineer. At the same time a subcontract administrator in the prime contractor organization assumed *he* had full responsibility for propulsion subcontracts on the program because another numbered company policy assigned responsibility for subcontracts to the procurement organization. Company management was (and may still be) unaware of these conflicting directives. The net result was that, although it was clear to the individuals involved who was responsible for strictly technical and subcontract administration aspects, neither was directly responsible for cost or schedule management and neither took effective steps to control the two propulsion subcontractors. The company's program manager, more interested in technical aspects than in cost and controls, assumed no direct responsibility for subcontract management. Costs galloped out of control while progress inched along on subcontractors' work.

Eventually the program manager and his Government counterpart were both replaced, largely because subcontract overruns contributed to a general loss of control.

If responsibility for subcontract or subprogram control is poorly defined in the prime contractor's organization, it is easy to imagine how confusing—and costly—this lack of definition is to the subcontractor who may be subject to conflicting directions from the prime's program manager, program engineer, subcontract administrator, general manager, director of procurement and perhaps his controller.

The DOD program manager can preclude this situation by obtaining from the prime contractor a documented statement saying who has specific responsibilities for cost, schedule and technical performance on each subcontract, and the prime program manager's responsibilities for subcontractor performance. Equally important, the DOD program manager should verify that subcontractors also receive such a statement; otherwise the effects of fragmented responsibility are sure to hit him in the pocketbook sooner or later.

### Plans and Controls

The Cost/Schedule Control Systems Criteria (C/SCSC) can aid greatly in subcontract control if a subcontractor has a validated C/SCSC system. Many prime contractors, in fact, prefer to team with a subcontractor who has a validated cost/schedule control system because it provides greater visibility into program status and subcontract administration is less costly. C/SCSC also helps to ensure that the subcontractor's plan is practical, comprehensive and meshes with the prime's program plan.

There is another area which might be termed "rigor" that is important in the prime contractor's management of subprograms.

A subprogram manager learns very quickly whether his customer, the prime contractor's program manager, has tight or loose reins, just as the prime contractor discovers this about his Defense Department counterpart. Where responsiveness is demanded, the subcontractor will be more apt to stay on top of his work. Laxness on the other hand invites unresponsiveness and, usually, higher costs. "Rigor" here

does not mean detail. It means the insistence on the prime and the subcontractor each doing what they said they were going to do.

Bearing in mind that the DOD program manager must take action through the prime contractor, some of the measures he can take to ensure rigorous management are these:

- Verifying the prime receives subcontractors' planning documents and reports *on the day they are due*, rather than the following day or later—and ensuring corrective action is taken if they are not promptly received.
- Detecting informal reports or reports other than those required by the prime's contract with the subcontractor. The existence of preliminary or working reports usually indicates those required by contract have deteriorated to eyewash (". . . the reliability problem reported in June is being resolved through aggressive management action. . . . ").
- Determining the effectiveness of corrective actions taken by the prime when the subcontractor reports deviations from his approved plan.
- Reviewing the subcontractor's reports, on a spot-check basis at the prime's facility, for meaning and timeliness; and comparing these reports with the prime's report to the Government for the same period.

By rotating his staff through attendance at the prime contractor's facility, the DOD program manager can greatly increase his visibility into how his program's dollar is being managed.

As a corollary, the prime contractor's program manager will almost always become more attentive to managing his subcontractors when he knows his customer has this visibility.

## Progress Reviews

Occasionally, early in his program, the DOD program manager should pick up his phone and ask his prime contractor counterpart, "Charlie? I'd like to sit in on your next progress review with Delta (subcontractor) on the guidance subsystem. Is that okay with you?" His industry counterpart may be thinking, "Progress review? I don't know about any progress review." But, quick on his feet, he responds, "Sure thing, Fred. I'm not sure just when my guys have it scheduled, but I'll get back in touch with you." Then he scrambles to schedule a review, sets up an agenda, and calls back. "Hello, Fred? Our next regular quarterly review is scheduled at Delta for the 11th of next month. Why don't you come out and join us there?"

In accompanying the prime on his visit to the subcontractor, the DOD program manager must scrupulously avoid giving direction to the subcontractor but he can ask any number of questions. Based on his staff's review of the prime's subcontract management and on the DCAS or plant representative's surveillance, he will know what questions to ask and how to evaluate the answers.

If the subcontractor has a project control center, he can also ask to review the subcontractor's plans and controls, including the plans and controls of lower tier subcontractors. And the DOD program manager can, of course, at any time give pertinent directions to the prime contractor's program manager.

## Summary

The most effective action in subcontracts management by DOD is the point at which the subcontractor is selected. After this, time effectively locks in a subcontractor, just as it does a prime contractor.

There are subsequent actions the DOD program manager can take in subcontractors' management, even though he has no privity of contract and must exercise control through his prime contractor. He can (must) ascertain that responsibility for subcontractor management is clearly defined, for both the prime and subcontractor organizations. He can determine the effectiveness of the subcontractor's plans and controls, and the prime's rigor in demanding the subcontractor meet program requirements. He can also take part as an observer in reviews of subcontractors' performance, in company with the prime.

These measures are not, of course, all-inclusive. But they are indicative of steps the DOD program manager can take in controlling the bulk of his contract costs, while keeping a "hands off" attitude toward subcontractors. The magnitude of defense procurement and the ever present money crunch demand that the DOD program manager find ways to get the most for his program's subcontract dollar. □

# Government Property Management: Criticism Versus Cost

The theory of a free enterprise economy visualizes the tools and equipment for production belonging to the individual manufacturers that compete in the marketplace. Government ownership of production facilities would appear to be an anathema. The Government, however, does own various types of production equipment and furnishes these items to commercial enterprises for use on more than 30,000 Government contracts. This deviation from private ownership is necessitated by the highly complex and specialized nature of military items, the advanced state of technology and the lack of commonality between military and commercial products.

Government property is defined in Section 13 of the Armed Services Procurement Regulation (ASPR) as all property owned by or leased to the Government, or acquired by the Government under the terms of a contract. Generally Government property is subdivided into five categories:

- Material incorporated into an end item under the contract.
- Military weapon systems and supporting equipment peculiar to military operations.
- Special test equipment such as electrical, hydraulics, mechanical or other items limited to testing a particular development or product.
- Special tooling such as jigs, dies, molds, etc., specifically designed for a certain production.
- Facilities used for production including real property, industrial plant equipment (those items used for the shaping, forming or actual production that cost $1,000 or more and are delineated in regulatory publications) and other plant equipment.

Although it is the policy of the Federal Government that the contractor will furnish all the means of production required for contract performance, the Government will acquire and provide the required equipment for reasons of economy or other appropriate circumstances. Each of the five types of property described is furnished to a contractor by the Government or he is permitted to acquire it for specific reasons. To ensure standardization, for example, the Government might furnish the cloth for the manufacturing of uniforms. Military property such as an Army tank could be provided for testing a con-

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*(This article was written while the author was completing his masters degree requirements at Harvard Graduate School of Business Administration and is based on information from Defense Contract Administration Services, Defense Supply Agency, Cameron Station, Alexandria, Va. Lt. Col. Kells is now assigned as District Commander, DCAS, Reading, Pa.)*

tractor's military end item. It behooves the Government to furnish the contractor special tooling and test equipment highly distinctive in nature from existing stocks, if available, rather than require new manufacture or new procurement that would result in increased contract costs. If such items are not available and yet required, the Government reserves the right to take title to the property upon contract completion and it, therefore, becomes Government property.

The Defense Contract Administration Services (DCAS), a major component of the Defense Supply Agency, was created for the explicit purpose of administering the terms and conditions of contracts entered into between DOD procurement activities and private industry. DCAS data serves as a vehicle for pursuing the analysis in this article. Since all DOD activities that administer contracts are bound by the same regulations, the theory will apply across the board.

## Magnitude

As of June 30, 1971, DCAS was administering contracts using the following amounts of Government property:

| | |
|---|---|
| Material | $ 743 million |
| Military Property | 993 |
| Special Tooling | 772 |
| Special Test Equipment | 647 |
| Facilities | 2,178 |
| Total | $5,285 million |

In view of the high Gross National Product, this amount may not seem like much but it represents an investment of more than $20 by each American citizen. Another way to judge the order of magnitude confronting DCAS property management is by comparison with industry. Of the 500 largest corporations in the country, only 37 have more than $5.25 billion invested in assets. Obviously property administration is big business.

## Present DCAS Method

The DCAS Industrial Property Management Division has the responsibility of assuring that Government property, provided to a contractor for the performance of his contract, is properly used, cared and accounted for and, when no longer required for contract performance, reported for redistribution and reutilization. Under the terms of his contract, the contractor is accountable and responsible for the property entrusted to his care and required to maintain the official Government property records. Industrial property administration takes into consideration the requirements of particular contracts and also evaluates the basic system of property management as applied by the contractor.

The actual function of industrial property administration is accomplished by testing and evaluating the contractor's system of property accounting and control. Entailed is a review and assessment of the contractor's procedures and a periodic survey of the system related to predetermined applicable categories of property control, namely: acquisition, receiving, records, storage and movement, consumption, utilization, maintenance, physical inventories, subcontract control, disposition and reports. The review covers the contractor's methods and techniques of property management and is conducted on a random statistical sampling basis. This effort develops a conclusion that the contractor's system is either satisfactory or unsatisfactory when compared to a table of limits permitting a tolerance for error. The principal service of the DCAS property administration function is to ascertain whether or not the contractor's system and practices of property management provide protection of Government property. When a contractor's system is found deficient in this respect, he must correct and improve his system so he can achieve and maintain a prescribed standard of care and control.

In March 1972, DCAS had 220 property administrators working to ensure the 4,308 contractor systems were maintained in an acceptable condition. On a nationwide average, each property administrator then was responsible for 19.6 systems with a total of 138 contracts and a dollar value of Government property slightly over $24 million. This is, indeed, an awesome individual responsibility. Because of the immensity of the workload, use of the system approach appears to be the most economical means of safeguarding the Government's investment. However, the system method is neither the perfect

solution nor does it provide 100-percent protection. It is an attempt to get the most for the least. There are bound to be holes in this type procedure and errors and mistakes will be made.

## Criticism

The management of Government property is audited by the General Accounting Office, the Defense Supply Agency's Auditor General, the Defense Contract Audit Agency, the DCAS Management Review Team and other organizations who are responsible for in-depth reviews and analyses of this activity. Basically deficiencies stem from two sources: unclear or ambiguous terms in the ASPR and the fact that neither the property administrators nor the system approach can guarantee 100-percent effectiveness.

To illustrate the former, ASPR requires the prior written approval of the contracting officer for any non-Government use of active Government owned industrial plant equipment. Before non-Government use exceeding 25 percent may be authorized, approval must be obtained from the Secretary of the Department concerned.[1] Additionally, non-Government use of machine tools and secondary metal forming and cutting machines in excess of 25 percent of the time the property is available for use previously required the approval of the Office of Emergency Preparedness (OEP) through the Assistant Secretary of Defense (Installations and Logistics). Now that OEP has been abolished and its functions transferred to other agencies, this ASPR requirement must be revised.

The term "available for use" caused considerable concern because a wide variety of definitions were applied. Recently DCAS issued a policy clarification of ASPR's intent that should rectify this problem area. The ASPR Committee should clarify this subject.

In another case, the ASPR requires the contractor to maintain a financial account of the items entrusted to his care. DCAS believes this accounting record is required for the annual financial report to satisfy provisions of Appendix B and C 311 of the ASPR, while the auditor envisions the contractor establishing a new and separate set of records providing a similitude of checks and balances. This disagreement helps substantiate the claim of ambiguity in the ASPR and indicates management time, which is being inappropriately used, could be applied to improve property administration. Although DCAS conducted studies and a pilot test that showed duplicate records were of dubious value and only increased contract costs, this problem is still not resolved.

The charge that the systems approach is not foolproof is reflected in two major areas of criticism of DCAS property administration: the unauthorized use of industrial property equipment (IPE) and the untimely reporting of excess IPE. It has been said that locks only keep honest people honest and the same analogy may be applied to property administrators (PAs). If a contractor wants to cheat the Government, he may eventually be caught by one of the review processes but there is no guarantee that the PA will uncover the problem.

## Cost versus Criticism

To provide complete assurance that the contractors do not use IPE for unauthorized purposes and promptly report excess IPE could require one man for each of the more than 90,000 separate items of IPE now in active use. This, of course, is ludicrous. To compare cost versus criticism for property management, assume that the average PA receives $10,000 annually including salary, fringe benefits and overhead. The annual cost for DCAS property management would then be $2.2 million. This is a property safeguarded to cost ratio of 2402 to 1. The probability of error free administration would lie somewhere on the vertical dotted line of Figure 1. Further, if the number of PAs were increased to provide one per system, it would assure 99 percent error free administration. The cost would then be $43 million and the ratio 123 to 1. This is point Y of Figure 1.

To carry this analysis one step further, assume that each property management system that is not error free receives criticism by audit teams and this costs $20,000 as a penalty for time, energy and embarrassment. It is agreed at the outset that this number is soft, but it does equal two man years in the computations. Therefore the new approach would cost $43 million + (.01) (4300 systems) ($20,000 penalty) = $43,860,000. This is

[1] *ASPR 13–405, April 30, 1971, Rev. 9, pp. 1343–4.*

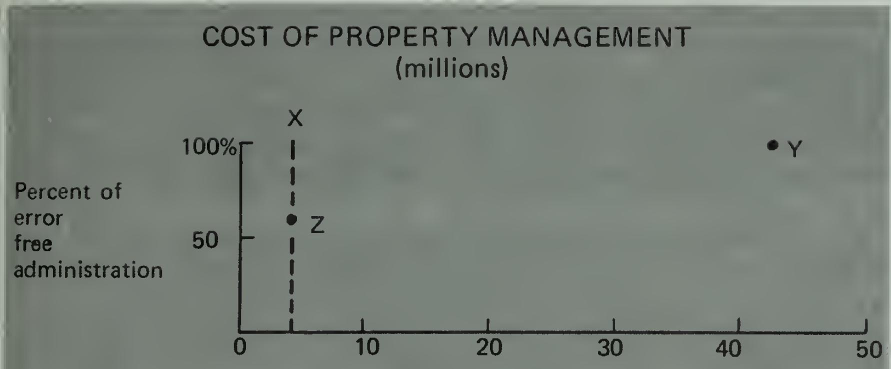

Figure 1

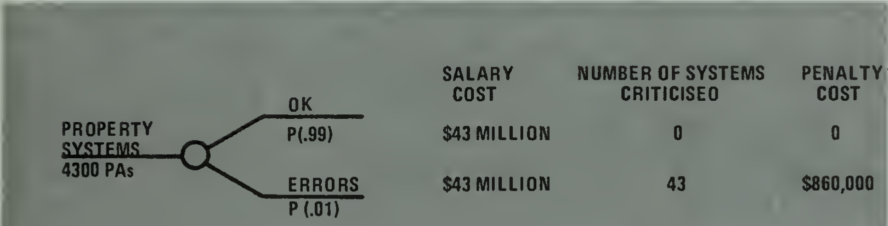

Figure 2

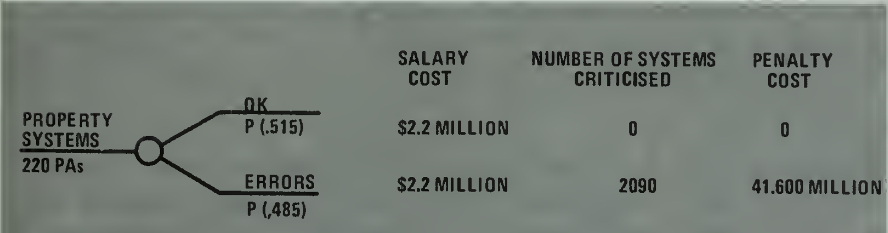

Figure 3

shown as part of a decision tree in Figure 2.

To ascertain the maximum percentages of bad systems that could exist under the present method and still cost less than the new process simply use the formula $2.2 million (A) + (1 — A) (2.2 million) + (1 — A) (4300) (20,000) = $43.86 million, where A = % of error free systems. This leads to the next decision branch (Figure 3).

Therefore, if DCAS has an error free rate greater than 51.5 percent (point Z of Figure 1), the better and less expensive course of action is the present method. It is interesting to note that if the penalty cost was raised to $50,000 the present method would be better if 80 percent or more of the systems were error free. This would leave 860 systems deficient, which is about the number of deficient systems DCAS detects and corrects annually, and it far exceeds the number disclosed by reviewing activities. In the real world, however, we do not know how many systems are error free although a best estimate would be 90 to 99 percent. Therefore we do not have a starting point on line X of Figure 1, and the slope of the line from this starting place to point Y is also unknown. Consequently, one must judge the incremental cost increase versus the incremental decrease in penalty or embarrassment cost before criticizing the present procedure.

## Summary

If a golden property mousetrap is not economically feasible, we must live with the present system and improve it to provide the most benefit for the least expenditure. Regulations must be clarified so contractors and all Government officials can agree on their meaning and intent. Through studies and tests, improvement on the present system approach can be made for selective disengagement (reduced system surveys) from those contractors who have low dollar value of Government property and those who have consistently demonstrated unquestionable care of such items. Then, DCAS property administrators may be used more judiciously to assure proper management on those systems that heretofore required more attention while austere conditions limited available personnel to perform the effort. The foregoing analysis appears to verify that the systems approach to property management, while not perfect, is the most economical and efficient method now available for protecting Government property furnished to industry for use in defense contract performance. □

## Conservation Is Necessary

# *DOD Faces Fuel Shortage: Future Will Be Difficult*

Over the years there have been many changes in the petroleum environment in which the Military Services, and the Nation as a whole, must exist. Surveying today's scene one can only conclude that on balance those changes have not been beneficial and, contrary to what is said, they are not a recent phenomenon. They were visible for a long time before assuming the menacing proportions of an oncoming tornado. Yet, while they may have been visible, they were heeded by few.

The petroleum security of the United States began running gently downhill in the middle 1950s, and steepened its decline in the 1960s. The decline has now approached the proportions of an avalanche, and like an avalanche, it will have to run its course for there is no quick or easy way of arresting the adverse progress of events.

**by Richard T. Mathews**
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***OASD (I&L)***

A few years ago we basked in the warm assurance of secure and adequate supplies of petroleum fuels, whatever our needs and whatever the course of events. Today that assurance is gone. The Nation now stands exposed to the risks of oil denials which might stem from political, economic or military causes. In the nearer term we lack significant capability to compensate for the energy shortages which would result from such denials. How then did we come to this condition?

### New Oil Difficult To Find

Geologists tell us the United States may have originally had over 700 billion barrels of discoverable oil. That's a lot of oil, but we have already discovered over half of it and have consumed most of that which can be produced from those discoveries. Worse, the greater portion of the discoveries was found more than 30 years ago. With the outstanding exception of Prudhoe Bay, new finds are harder and harder to come by. The downturn in explora-

tion began in the late 1950s and has continued ever since. The development of new reserves ebbed, while demand steadily rose and we slowly eroded our spare producing capacity. Then, in 1967, imports exceeded spare capacity for the first time and we became an oil deficit nation.

Several other factors entered the oil equation and began to contribute to that deficit. Rising affluence created ever increasing demand for petroleum fuel. New gas discoveries began to fall short of replacing production and the environmental issue appeared, helping to increase the demand for gas to replace dirty oil and dirtier coal and forcing excessive consumption of petroleum resources in the quest for cleaner air and water. During the last five years, additional factors have combined to produce petroleum demands far beyond those previously foreseen, while simultaneously inhibiting the use of abundant fuels such as coal and uranium. Enormous demands have been put on oil and gas just as those two fuels reached their maximum production capacity in this country and approached a period of decline.


The only ready answer to the gaps in energy supply thus created was to import more oil. Since 1970, oil imports have grown at an accelerating pace and this year they will provide about 35 percent of all the oil and over 15 percent of the energy consumed in this country. Since 1971 the Western Hemisphere has been a net oil deficit region, necessitating increased oil imports from Eastern Hemisphere sources, mostly in the Arabian Gulf area of the Middle East.

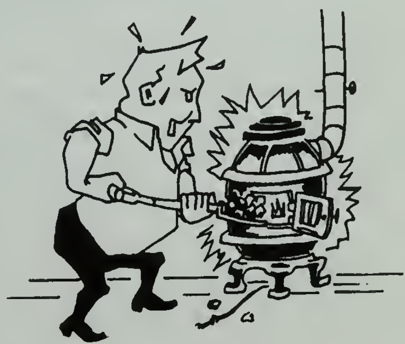
Another factor contributing to our difficulties is that there is not a single new refinery under construction in this country. The existing refining industry is only marginally capable of meeting today's demand, if you don't count residual fuel which is already heavily dependent on imports. Demand for 1975 is projected to increase by nearly 2 million barrels a day more than in 1973, before any significant new refinery capacity can possibly come on stream. Obviously 1973 is the last year in which we will see large increases in crude oil imports. Lacking the refineries to process more crude, the United States will probably have to turn increasingly to product imports in the coming years to ensure adequate supply and avoid shortages.

### Fuel Availability Lessens

So much for background. Where are we now, and what can we look for in the years ahead?

In our current energy situation, interruptible customers of natural gas lost their supply with increasing frequency last winter, forcing them to turn to oil products which are also in short supply. The shortage of heating oil has impacted on the supply of diesel fuel. During the summer of 1972 there were tight spots in the gasoline markets. This summer I expect there will be much more tightness and spot shortages are not out of the question. Even crude oil has been a problem. Refiners in the United States, and in some foreign areas, too, had some difficulty last winter in obtaining the right kinds and quantities of crude to meet their needs.

The Department of Defense has not been immune to these trends. In September 1972, there was a distinct lack of interest in selling jet fuel to military consumers. Offers were barely adequate to meet domestic military consumption needs, a situation unprecedented in the last 15 years. Prices were sharply higher in all source areas. The disturbing implications



of that procurement, in a few short months, were transformed into very unpleasant realities.

In December 1972, the Defense Fuel Supply Center failed to get full coverage from offshore refiners on a supplemental jet fuel buy to meet Pacific military requirements. A second solicitation for a larger quantity was extended to both offshore and domestic refiners in an attempt to ensure full coverage. The offers covered only 30 percent of the requirement. Industry offers against more recent regular solicitations have fallen 50 percent or more short of meeting requirements, and prices have climbed 35 to 40 percent, threatening to add $400 to $500 million to annual DOD fuel costs —if we can get the product.

The future implications of this situation need no elaboration. For the first time since World War II DOD faces the possibility it may not be able to routinely provide all the fuel needed by the Armed Forces.

Part of the jet fuel problem can be attributed to the lack of adequate domestic refining capacity. Another consideration is the exploding naphtha demand for petrochemical feedstocks for the synthesis of natural gas and to augment gasoline plant inputs. Naphtha was only recently a refining byproduct readily available at prices well below other product realizations. Now it is in such demand that buyers who offer anything but a favorable long term contract are apt to find little to buy. The long standing DOD practice of employing short term procurement cycles is no longer compatible with changing market conditions and is impacting adversely on our ability to compete successfully in today's and tomorrow's markets of scarcity. Some rethinking appears necessary.

## Entire Nation Affected

Many of our military installations suffered gas interruptions last winter and replacement oil has become increasingly scarce. The Army has had to ship Arctic diesel fuel by tank car and tank truck from Puget Sound to Nebraska and Colorado to keep facilities operational. Many similar uneconomical movements have been required.

DOD has also been under considerable pressure to provide assistance from DOD stocks to the civil economy. While willing to do so, the assistance DOD can provide is woefully inadequate considering a civil demand for well over 3 million barrels per day of distillate fuels. The total quantity DOD can spare without interfering with the military mission is only 900,000 barrels—just a few hours supply.

In regard to jet fuels, it is not only JP–4 that is in trouble. Just as the competition for naphtha has cut into the normal sources of supply, so has the overriding need to maximize

the production of kerosene and No. 2 heating oil cut into the supply of commercial jet fuel. For example, serious shortages of fuel have occurred at Kennedy International Airport in New York. Last January OEP asked the Department of Defense to lend some jet fuel to an oil supplier at Kennedy Airport to maintain operations.

### Future Appears Grim

The future is far from reassuring. All the adverse conditions previously cited will probably grow a good deal worse before they can grow better. Because of reduced domestic oil production and virtually frozen refinery capacities, imports of oil and refined products will increase rapidly. We will become heavily dependent on middle eastern oil resources and foreign refineries in Europe and in the Western Hemisphere. There will be serious adverse impact on the balance of payments. Prices will continue to rise as the producing nations increase their take from each barrel produced, and the costs of exploration and development move upwards. Tight markets in various products may recur with increasing frequency and meeting defense fuel requirements will become more and more difficult. Adequate industry responsiveness to emergency requirements will no longer be something to be taken for granted. Whenever shortages occur, as they are likely to do, there will be calls for DOD to reduce its consumption of petroleum and to make its inventories available to augment supply.

The next few years promise to be difficult. Aside from the parochial problems which DOD may encounter, the most important considerations are those affecting the Nation's security and the well-being of the populace. By 1980 the United States is likely to be dependent on foreign sources for 50 percent or more of its oil needs and 25 to 30 percent of its total energy supply. Much of the supply will originate in areas with a potential for political and economic unrest which could impact adversely on the supply of energy fuels. Oil from those areas must be transported to the United States over very long routes with a high degree of vulnerability to enemy action in the event of war. Even if we discount these dangers to our future security, there is one additional consideration which must command the Nation's attention and spur our actions if we are to sustain security and economic vitality in the years beyond this decade.

That consideration is the simple possibility the supply of oil may not keep pace with the world's needs. The energy demands of the world are doubling every 10 years or so. Oil supply is the only area which holds out the promise of fulfilling demand through most of the rest of this century. The specialists tell us there is enough oil already found or likely to be found to supply the world into the 1990s. But will it be produced at a rate that will meet world requirements? There is a good possibility it will not.

Indications exist in one producing country after another of a growing awareness of the exhaustible nature of the oil and gas which, in most cases, constitutes their only significant resource and income. Some countries have already restricted production and others are considering restrictions. Prudence dictates we must proceed on the assumption that by the end of this decade most of the world's oil exporting nations will have imposed production restrictions in the interests of conserving their remaining resources and extracting the maximum possible financial return from each unit of production. If that conclusion is correct, our petroleum fuel supply in the 1980s will increasingly depend on our capacity to enlarge the domestic energy fuel production base or, failing that, an attempt to outbid our international friends and allies for energy fuel supplies available in the world marketplace.

### Other Energy Prospects

The picture is bleak but this Nation has the capacity to reverse the existing trends and restore a reasonable degree of energy self-sufficiency over the longer term. Fortunately, the United States has large coal and uranium resources. Although domestic oil and gas are unlikely to ever again meet the demand for them, there are still vast quantities of both in the ground to be discovered or recovered from existing discoveries. Both can be augmented by oil and gas produced from coal and oil shale.

Nearby nations possess enormous undeveloped deposits of tar sands and heavy oils which, over time, hold forth the prospect of signifi-

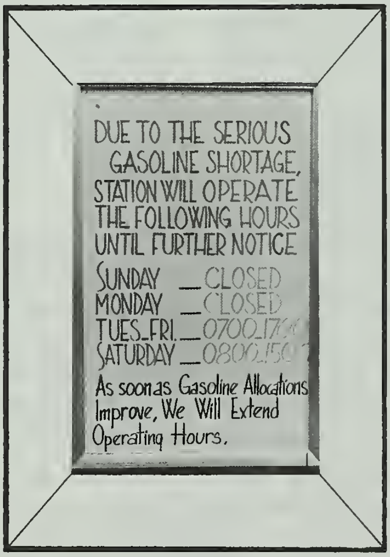
cantly contributing to the hemisphere's fuel needs. The conflicting needs of the environment and the petroleum fuel industry can be reconciled and we can begin once again to build refineries in this country. I am confident we will soon be starting on the long road back to a secure posture in our petroleum fuel needs.

### Conservation a Necessity

Perhaps the most important step which we can take is in the field of conservation of fuel. The Government, industry and the public must all realign their thinking concerning fuel. In the past, with seemingly unlimited supplies of any desired energy fuel, we have given little thought to conservation and the proper use of fuel. We have been concerned mostly with cost or convenience without regard to misuse of premium fuels and without thought of inefficient or wasteful use. For instance, we burn artificially low priced natural gas, an item in short supply, under boilers where coal, which is plentiful, would suffice. The Nation must learn to conserve the use of energy fuels and avoid waste, to slow the exponential growth in consumption. Unless that growth is slowed, I doubt any amount of expenditure and effort will suffice to regain an acceptable degree of energy fuel self-sufficiency in this century.

We must not deceive ourselves. The energy crisis is real; it is far worse than most people recognize; and it is going to get worse before it gets better. Fifteen percent of our energy supplies are already dependent on the sufferance of foreign nations and, before our best efforts can hope to reverse that trend, that dependence may reach 30 percent and an adequate supply may not be obtainable.

There is no quick, inexpensive route to energy security. It will be a long hard road, the journey will be very costly and, probably at various times and in various places, uncomfortable and unpopular. But it is a journey we cannot afford to forego if this Nation is to remain secure and provide a continued high standard of living for its people. □



## Acquisition Objective

*(continued from page 6)*

"boiler plate." We will also look to competition to help us reduce costs and improve field reliability. We will emphasize the competitive prototype approach, maintaining competition during the development phase and for as long thereafter as economically practical.

In essence, we must and will change the way of doing business. To do this, we need dedication, proper emphasis and correct incentives. We expect the studies and experiments now being pursued will aid us in this transition. We will also require understanding and support at all levels of DOD and industry.

Our objectives are to acquire low cost, capable and reliable defense systems that we can afford to buy and operate in sufficient numbers. Only in this way will we be able to equip and maintain military forces adequate for national security. □

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## Low Ownership Cost

*(continued from page 24)*

and inventory storage points, training activities and communications and data handling systems. The costs indicated by curve II in Figure 3 include an appropriate proportion of all backup costs. Overall costs on curve II are therefore *much* higher.

The true increment of support cost avoidance possible through improved reliability is much more marked using full costs. In reality, less depot capability and fewer maintenance personnel with their associated base operating support, training pipelines and facilities are required for the more reliable system. It is, therefore, worth expending a great deal of effort to obtain systems supportable in the customer's environment. □

# *GSA To Maintain Procurement Library*

The Commission on Government Procurement has made arrangements with the General Services Administration (GSA) for the maintenance of the library it has acquired over the past three years. The library contains an extensive body of literature on procurement as well as the full report of the Commission.

In its final report to the Congress, the Commission recommended the creation of a Federal Procurement Institute that would be responsible for research and education in the field of Government procurement and general advancement of the art. If such an institute were established the Commission's library would become part of it.

The arrangements call for the library to be run by GSA's Federal Supply Service. The address is:

Commission on Government Procurement Library<br>
Room 632<br>
Crystal Mall Building #4<br>
Washington, D.C. 20460

The Commission on Government Procurement expired by law on April 30, 1973.

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# ISA Conference

"Energy Conservation Through Instrumentation" will highlight the 28th Instrument Society of America (ISA) International Conference and Exhibit to be conducted October 15–18 at the Astrohall, Houston, Tex.

A comprehensive review of the latest advances in instrumentation is scheduled through technical sessions and equipment displays. Special focus will be on instrument markets in pollution control, chemicals, petroleum, metals, gas transmission and power.

The Second Joint Environmental Instrumentation and Control Symposium and the Seventh Data Handling and Computation Symposium will be held concurrently with the conference.

# a few words about...

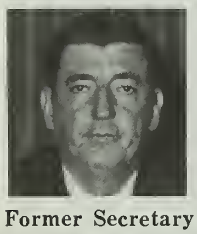
## *Presidential Certificates Awarded*

Presidential Management Improvement Certificates were presented by former Secretary of Defense Elliot L. Richardson to five Department of Defense individuals and groups during a ceremony at the Pentagon April 18.

The Certificates are awarded by the President for important and noteworthy accomplishments in the field of management improvement. The five individuals and groups were chosen by the President's Advisory Council as deserving special recognition in receipt of the Presidential Certificate for their accomplishments during Fiscal Year 1972. They are:

- George V. Johnson, U.S. Army Troop Support Command, St. Louis, Mo., for developing two S-curve models which expanded the S-curve concept of cost estimating to include research and development costs and their relation to production costs.
- Mrs. Evelyn E. Schumacher, Naval Weapons Station, Concord, Calif., for developing an imaginative campaign to eliminate unnecessary paperwork at the station.
- Captain Richard C. O'Loughlin, USN, Naval Air Station, Jacksonville, Fla., for accommodating a 20-percent workload increase in the station's supply department while making a 10-percent cut in personnel for a cost benefit estimated at more than $450,000.
- Office of Manpower Utilization, Headquarters, U.S. Marine Corps (Quantico, Va.), for developing a program to ensure placement of the right man in the right job which will save the Marine Corps several million dollars over the next few years. (Colonel George Caridakis accepted the award for the office.)
- Air Force Satellite Control Facility, Sunnyvale, Calif., for providing support of 52 DOD satellites and 15 percent more data and support to individual programs while considerably reducing its budget and manpower. (Colonel John J. Schmitt Jr. accepted the award for the facility.)

A complete listing of the Department of Defense recipients of the Presidential Management Improvement Certificates can be found on page 72 of the April 1973 issue of the *Defense Management Journal.*



Former Secretary of Defense Elliot Richardson presents the Presidential Management Improvement Certificate to George V. Johnson, Department of the Army, at a Pentagon ceremony. Other individual recipients were Mrs. Evelyn Schumacher and Captain Richard C. O'Loughlin, USN, of Department of the Navy.

## DOD Holds Tech Data Workshop

A Department of Defense workshop on technical data management was held at the Army Missile Command, Huntsville, Ala., March 27–30. Representatives of the Military Departments, Defense Agencies and defense industries met in panels to discuss ideas for improving the way the DOD buys and stores technical and engineering data. The panels covered Data Acquisition Management, Data Requirements Management, Administration of Contract Data, Storage and Retrieval, and Advanced Data Concepts.

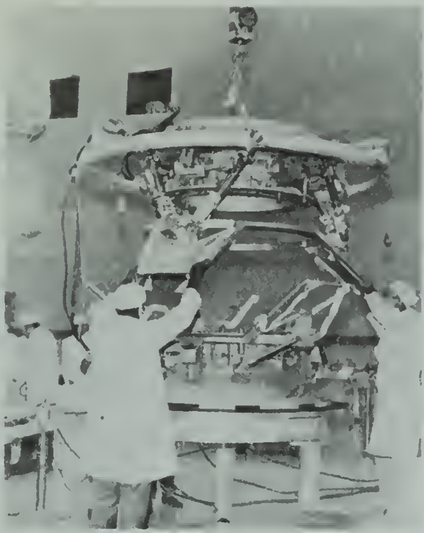
The industry and DOD panels submitted approximately 65 recommendations for evaluation by the Office of the Assistant Secretary of Defense (Installations and Logistics) and the Military Services.

## AFSC Cuts Wind Tunnel Costs

A group of engineers and technicians at the Air Force Systems Command's Arnold Engineering Development Center, Arnold AFS, Tenn., has developed a technique for saving time in changing conditions in the Center's transonic wind tunnel. By combining a process control unit with a television-like remote terminal, the Center has been able to save two of the five minutes formerly required to change test conditions in the tunnel. The changes can now be monitored simultaneously by all of the operating personnel involved. The equipment used in the project was formerly used for control functions only in jet engines.

Based on a $2,400 an hour cost to operate the tunnel, the Air Force will save approximately $250,000 a year by using the new technique. In addition to the money savings, the new system is more accurate, more precise and almost totally eliminates the taking of off-condition data.

Data processor (left) coupled with an interactive terminal gives operating personnel immediate and simultaneous information on exact conditions in the transonic wind tunnel.



Docking system for the joint United States-Soviet Union space mission is tested at Rockwell International Corporation's Space Division. It is the first full-scale test component for the mid-1975 flight, which will be history's first international space mission.

## Air Force To Get New Video Mapper

Air Force has developed a new electronic video mapper to assist air traffic controllers in "seeing" where an aircraft is in relation to mountains, tall buildings and major landmarks within 10 to 200 miles from a runway.

Developed by the Air Force Systems Command's Electronic Systems Division, L. G. Hanscom Field, Mass., a total of 160 mappers are being produced bearing the designation "Video Mapping Group AN/GPA-131 (V)."

The video mapping system combines, in a single visual display, two images—one a high quality terrain and obstacle map and the other the normal radar scope image.

The Air Force will receive 130 units and the FAA will receive 30 units. Delivery should be completed by August 1973.

## *PROMPT Brochure*

The NAVAIR PROMPT (Project Reporting, Organization, Management Planning Techniques) Management System brochure has been published by the Naval Air Systems Command to assist in implementing general management requirements for project management specified in Aeronautics Requirement Document, AR-59.

The brochure gives a brief historical review of PROMPT's development and presents simply the approach on the selection of those management requirements most closely satisfying the needs for project management. In addition, it documents the steps to be followed in the application of PROMPT.

The brochure is available from the Department of Navy, Naval Air Systems Command, AIR-103, Washington, D.C. 20360.

## Navy R&D Center Saves $7 Million

The Naval Ship Research and Development Center, Bethesda, Md., through its Cost Reduction Program, achieved over $7 million in cost reductions during Fiscal Year 1972.

The most significant saving was in the Computation and Mathematics Department where $4,380,000 was saved by the use of a computer aided ship design program which eliminated the need for manual computations. The Ship Performance Department realized a saving of $1,040,000 by eliminating box keels on the patrol gunboat class, a change that also improved performance.

# Secretary of Defense

James R. Schlesinger, former Director of the Central Intelligence Agency, succeeded Elliot L. Richardson as Secretary of Defense. Mr. Richardson has assumed duties as the Attorney General of the United States.

Since 1969 Mr. Schlesinger has served as Assistant Director of the Bureau of the Budget, Acting Director of the Office of Management and Budget and Chairman of the Atomic Energy Commission.

Prior to 1969 he was the Director of Strategic Studies at the Rand Corporation where he specialized in strategic analysis with special references to nuclear weaponry.

Mr. Schlesinger holds B.A., M.A. and Ph.D. degrees from Harvard University.

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